5-2012

The Deepwater Horizon Oil Spill Disaster: A Graphical Assessment of its Impact on Wildlife

Anvar Suyundikov
Utah State University

THE DEEPWATER HORIZON OIL SPILL DISASTER: A GRAPHICAL ASSESSMENT OF ITS IMPACT ON WILDLIFE

by

Anvar Suyundikov

A report submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Statistics

Approved:

Dr. Jürgen Symanzik Major Professor	Dr. Daniel Coster Committee Member

Dr. Yan Sun
Committee Member

UTAH STATE UNIVERSITY
Logan, Utah

2012

ABSTRACT

The Deepwater Horizon Oil Spill Disaster: A Graphical Assessment of its Impact on Wildlife

by

Anvar Suyundikov, Master of Science

Utah State University, 2012

Major Professor: Dr. Jürgen Symanzik
Department: Mathematics and Statistics

The Deepwater Horizon oil spill occurred in the Gulf of Mexico on April 20, 2010. Considered the largest accidental marine oil spill in history, oil flowed for three months and approximately five million barrels of oil spilled through by mid-July 2010. In this report, we analyse *fish* and *bird* data to assess the impact of the oil spill on the Gulf wildlife. Our findings based on the available fish data for 2005, 2006, and 2010 are not very helpful to make a judgement on the negative impact of the oil spill on fish species. On the other hand, the bird data analysis shows that the closer the surface oil spill area approached to bird habitats, the more dead birds were observed. The highest number of dead birds was observed in July and August when birds bred and raised their offspring. However, the migration behaviour of different bird species makes it impossible to entirely estimate the full impact of the oil spill on birds.

(362 pages)

ACKNOWLEDGMENTS

I would like to thank my advisor Dr. Jürgen Symanzik for spending countless hours in assistance and guidance over the completion of this project. His wisdom, knowledge, and commitment to the highest standards inspired and motivated me. I would like to give credit to his STAT 6560 Graphical Methods where I acquired indispensable knowledge and skills to finish my project. I would also like to thank Drs. Daniel Coster and Yan Sun for serving on the committee and for helpful suggestions.

I would also like to thank Cindy, a Staff of the Department of Mathematics and Statistics for her technical assistance throughout the paper's defense. I would also like to acknowledge the Latex template provided by Mark Schmelter, a former master student of the department.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Database Abbreviation

PAHs	Polycyclic Aromatic Hydrocarbons
ANT	Anthracene
BAA	Benz[a]anthracene
BaP	Benzo[a]pyrene
CHR	Chrysene
FLA	Fluoranthene
FLU	Fluorene
NPH	Naphthalene
PHN	Phenanthrene
PYR	Pyrene

AMSA	Australian Maritime Safety Authority
ASA	American Statistical Association
EMPSR	Experimental Marine Pollution Surveillance Report
EPA	United States Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FDA	United States Food and Drug Administration
GDAL	Geospatial Data Abstraction Library
GIS	Geographic Information Systems
JSM	Joint Statistical Meetings
NESDIS	National Environment Satellite, Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
NWF	National Wildlife Federation
SAB	Satellite Analysis Branch
SAR	Synthetic Aperture Radar
USFWS	United States Fish and Wildlife Service

CHAPTER 1
INTRODUCTION

The Gulf of Mexico is an ocean basin largely surrounded by the North American continent and the island of Cuba. It is bounded on the northwest, north, and northeast by the Gulf Coast of the United States (Texas, Louisiana, Mississippi, Alabama, and Florida), on the southwest and south by Mexico, and on the southeast by Cuba. It is one of the largest marine ecosystems on the North American continent.

On April 20, 2010, the catastrophic explosion of the Deepwater Horizon oil platform (28.44^{o}N, 88.23^{o}W), located in the Mississippi Canyon about 62 km off the Louisiana coast, was the biggest environmental threat in the Gulf of Mexico history so far. It was also the largest accidental marine oil spill in the history of the petroleum industry. Nearly five million barrels of oil have gushed from the oil well and only about 800,000 barrels of oil have been captured by containment efforts[1]. Figure 1 lists major attempts in capping of the Deepwater Horizon oil spill in the Gulf of Mexico. The timeline in Figure 1 shows that the oil leak was plugged successfully with using a tightly fitting cap on July 15, 2010. On September 19, 2010, after pressure testing of the "bottom kill" sealing, the oil wellhead was declared "officially dead". R code for Figure 1 can be found in Appendix B.1.1.

However, the ecological impact of the release of such a huge amount of crude oil is not fully understood, even two years after the disaster. This oil spill likely will have a long-term effect on marine, coastal, and deltaic ecosystems of the Gulf of Mexico.

The Australian Maritime Safety Authority (AMSA) provided the following information regarding the effects of oil on wildlife. In particular, the impact of oil on

[1] `http://www.nytimes.com/2010/08/03/us/03spill.html?_r=2&fta=y`

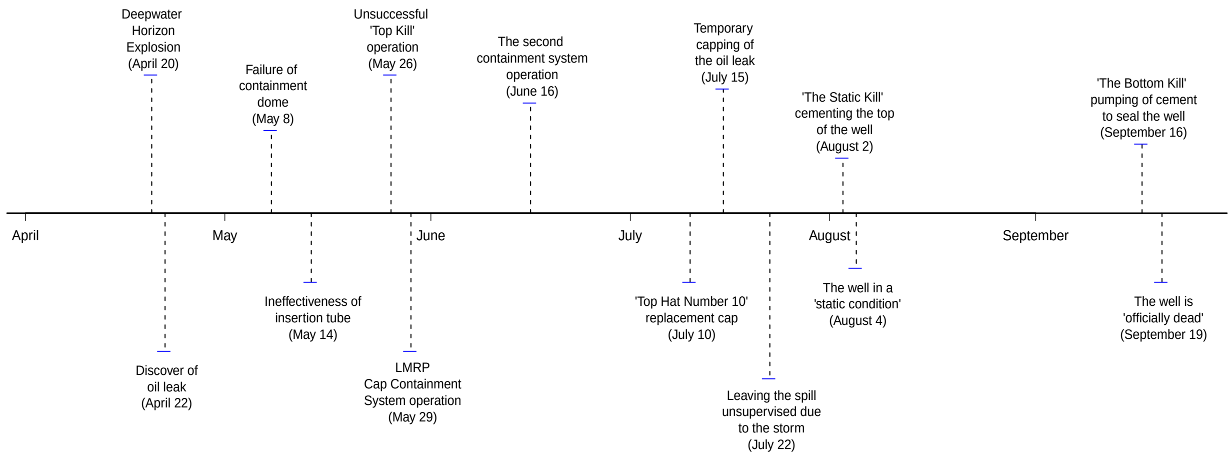


Fig. 1: The timeline of the Deepwater Horizon oil spill

wildlife depends on[2]:

- the type of oil spilled,
- the location of the spill,
- the species of wildlife in the area,
- the feeding and breeding behaviours of species,
- and even the weather at sea during the oil spill.

Further, AMSA stated: "Oil affects wildlife by coating their bodies with a thick layer. Many oils also become stickier over time (this is called weathering) and so adheres to wildlife even more. Since most oil floats on the surface of the water it can effect many marine animals and sea birds. Unfortunately, birds and marine mammals will not necessarily avoid an oil spill. Some marine mammals, such as seals

[2]http://www.amsa.gov.au/marine_environment_protection/educational_resources_and_information/teachers/the_effects_of_oil_on_wildlife.asp

and dolphins, have been seen swimming and feeding in or near an oil spill. Some fish are attracted to oil because it looks like floating food. This endangers sea birds, which are attracted to schools of fish and may dive through oil slicks to get to the fish.

Oil that sticks to fur or feathers, usually crude and bunker fuels, can cause many problems. Some of these problems are:

- hypothermia in birds by reducing or destroying the insulation and waterproofing properties of their feathers;
- hypothermia in fur seal pups by reducing or destroying the insulation of their woolly fur (called lanugo). Adult fur seals have blubber and would not suffer from hypothermia if oiled. Dolphins and whales do not have fur, so oil will not easily stick to them;
- birds become easy prey, as their feathers being matted by oil make them less able to fly away;
- marine mammals such as fur seals become easy prey if oil sticks their flippers to their bodies, making it hard for them to escape predators;
- birds sink or drown because oiled feathers weigh more and their sticky feathers cannot trap enough air between them to keep them buoyant;
- fur seal pups drown if oil sticks their flippers to their bodiesk;
- birds lose body weight as their metabolism tries to combat low body temperature;
- marine mammals lose body weight when they can not feed due to contamination of their environment by oil;

- birds become dehydrated and can starve as they give up or reduce drinking, diving and swimming to look for food;
- inflammation or infection in dugongs and difficulty eating due to oil sticking to the sensory hairs around their mouths;
- disguise of scent that seal pups and mothers rely on to identify each other, leading to rejection, abandonment and starvation of seal pups; and
- damage to the insides of animals and birds bodies, for example by causing ulcers or bleeding in their stomachs if they ingest the oil by accident"[2].

Moreover, AMSA indicated: "Oil does not have to be sticky to endanger wildlife. Both sticky oils such as crude oil and bunker fuels, and non-sticky oils such as refined petroleum products can affect different wildlife. Oils such as refined petroleum products do not last as long in the marine environment as crude or bunker fuel. They are not likely to stick to a bird or animal, but they are much more poisonous than crude oil or bunker fuel. While some of the following effects on sea birds, marine mammals and turtles can be caused by crude oil or bunker fuel, they are more commonly caused by refined oil products.

Oil in the environment or oil that is ingested can cause:

- poisoning of wildlife higher up the food chain if they eat large amounts of other organisms that have taken oil into their tissues;
- interference with breeding by making the animal too ill to breed, interfering with breeding behaviour such as a bird sitting on their eggs, or by reducing the number of eggs a bird will lay;

- damage to the airways and lungs of marine mammals and turtles, congestion, pneumonia, emphysema and even death by breathing in droplets of oil, or oil fumes or gas;
- damage to a marine mammal's or turtle's eyes, which can cause ulcers, conjunctivitis and blindness, making it difficult for them to find food, and sometimes causing starvation;
- irritation or ulceration of skin, mouth or nasal cavities;
- damage to and suppression of a marine mammal's immune system, sometimes causing secondary bacterial or fungal infections;
- damage to red blood cells;
- organ damage and failure such as a bird or marine mammal's liver;
- damage to a bird's adrenal tissue which interferes with a bird's ability to maintain blood pressure, and concentration of fluid in its body;
- decrease in the thickness of egg shells;
- stress;
- damage to fish eggs, larvae and young fish;
- contamination of beaches where turtles breed causing contamination of eggs, adult turtles or newly hatched turtles;
- damage to estuaries, coral reefs, seagrass and mangrove habitats which are the breeding areas of many fish and crustaceans, interfering with their breeding;
- tainting of fish, crustaceans, molluscs and algae;

- interference with a baleen whale's feeding system by tar-like oil, as this type of whale feeds by skimming the surface and filtering out the water; and
- poisoning of young through the mother, as a dolphin calf can absorb oil through it's mothers milk"[2].

Finally, AMSA concluded: "Animals covered in oil at the beginning of a spill may be affected differently from animals encountering the oil later. For example, early on, the oil maybe more poisonous, so the wildlife affected early will take in more of the poison. The weather conditions can reduce or increase the potential for oil to cause damage to the environment and wildlife. For example, warm seas and high winds will encourage lighter oils to form gases, and will reduce the amount of oil that stays in the water to affect marine life.

The impact of an oil spill on wildlife is also affected by where spilled oil reaches. For example, fur seal pups are affected more than adults by oil spills because pups swim in tidal pools and along rocky coasts, whereas the adults swim in open water where it is less likely for oil to linger. Dugongs als feed on seagrass along the coast and therefore be more affected by oil spills"[2].

One major effort towards the visual assessment of the Deepwater Horizon oil spill impact on wildlife was the Data Exposition at the Joint Statistical Meetings (JSM) of the American Statistical Association (ASA) in 2011. The Data Exposition, commonly known as the Data Expo, is held every two or three years and it is sponsored by the ASA Sections on Statistical Graphics and Statistical Computing. In 2011, poster presenters were asked to use the data sets posted on `http://streaming.stat.iastate.edu/dataexpo/2011/` for their graphical analyses of the oil spill. This Data Expo web site contains data sets collected by the National Oceanic and Atmospheric Administration (NOAA), United States Environmental Protection Agency (EPA), and United States Fish and Wildlife Service (USFWS). Table 1 lists the data sets with their sources.

Table 1: The Deepwater Horizon oil spill data sets

Number	Data set	Data source
1	glider	NOAA
2	boats	NOAA
3	floats	NOAA
4	fisheries: baseline, June2010	NOAA
5	sampling	EPA
6	monitoring	EPA
7	birds	USFWS
8	turtles	USFWS
9	mammals	USFWS

Two published articles of entries from the 2011 Data Expo provided a graphical assessment of the oil spill impact on wildlife. Particularly, “Effects of Oil Spill on Birds: A Graphical Assay of the Deepwater Horizon Oil Spill’s Impact on Birds” by Yazdanparast et al. (2011) showed the impact of the oil spill on bird species. “When Oil and Water Mix: Temperature and Salinity Changes in the Gulf after the BP Catastrophe” by Lee and Marcovitz (2011) found a salinity reduction of the ocean water after the oil spill and a temperature decrease in the Gulf of Mexico in fall 2010 followed by a warm winter. Beside the Data Expo publications, “Effects of Oil Spills on Marine and Coastal Wildlife” by Ober (2010) showed that the off-shore oil spills can have a large impact on many components of natural ecosystems. “The Deepwater Horizon Oil Spill: Coastal Wetland and Wildlife Impacts and Response” by Corn and Copeland (2010) gave a comprehensive report of the oil spill impact on the Gulf wildlife. A third article by Li et al. (2011) that resulted from the 2011 Data Expo dealt with the data from gliders, boats, and floats, but not with Gulf wildlife. The interactive map on `http://www.nytimes.com/interactive/2010/05/01/us/`

`20100501-oil-spill-tracker.html` may give an overall idea about the movement of the oil spill area in relation to the estimated amount of the spilled oil. Additional information about the oil spill and its impact on wildlife can be obtained from USFWS[3] and NOAA[4].

Though the oil spill affected a large number of Gulf animals, we concentrate our research only on fish and bird species. In Chapter 2, we visualize the impact of the oil spill on fish species, particularly on white shrimp. White shrimp is one of the most popular fish species in the Gulf of Mexico and is mainly observed in available fish data for 2005, 2006, and 2010. This chapter examines the polycyclic aromatic hydrocarbons (PAHs) concentration levels that were observed in white shrimp in 2005, 2006, and 2010 with their spatial and temporal locations. We assess the spatial and temporal locations of white shrimp in relation to the spread of the Gulf oil spill.

In Chapter 3, we visualize the bird species in the framework of the Deepwater Horizon oil spill. Particularly, we concentrate our research on the three most frequently observed bird species: laughing gull, brown pelican, and northern gannet. These bird species are migratory shore birds. We analyse these bird species by months, oiling condition (not visibly oiled, unknown, and visibly oiled), and living (dead or live) status in relation to the oil spreading area.

Chapter 4 describes additional geovisalization packages in R that were explored, but ultimately were not used in Chapters 2 and 3. This chapter also summarizes how to manage remote sensing data with different R packages.

We finish with a discussion and outlook in Chapter 5. Appendix A contains the additionally produced plots, while Appendix B includes R code for all plots presented in this report.

[3] `http://www.fws.gov/`

[4] `http://www.noaa.gov/`

The fish and bird analyses have been carried out in R and the graphical plots in Chapters 2 and 3 have been produced by using R packages *RgoogleMaps* (Loecher et al., 2012) and *PBSmapping* (Schnute et al., 2012). This report was written in *LaTex* (Lamport, 1984).

CHAPTER 2

FISH

2.1 General Background

The key component of estimating the oil spill damage to the Gulf fish is the toxicity concentrations in fish species. The toxicity concentrations which were observed in fish species are the components of polycyclic aromatic hydrocarbons (PAHs); nine components are of particular interest: Anthracene (ANT), Benz[a]anthracene (BAA), Benzo[a]pyrene (BaP), Chrysene (CHR), Fluoranthene (FLA), Fluorene (FLU), Naphthalene (NPH), Phenanthrene (PHN), Pyrene (PYR).

Only these nine PAHs components were observed in the fish species that we are going to study later in this chapter. Since the results of ANT and PHN were combined as one toxicity concentration in the fish data, we will consider them together in this paper.

Table 2 lists the observed components of PAHs and their chemical properties. The chemical formula, sometimes used as a molecular formula, expresses information about the atoms that constitute a particular chemical compound. For example, $C_{18}H_{12}$, the chemical formula for BAA, indicates that BAA consists of eighteen carbon atoms and twelve hydrogen atoms. CHR has the same chemical formula, but a different chemical layout.

In chemistry, the molar mass is defined as the mass of a given substance (chemical element or chemical compound) divided by its amount of substance[1]. The amount of a chemical substance is expressed in mole, a unit of measurement used in chemistry. The mole is defined as an amount of a substance that contains as many elementary

[1] http://old.iupac.org/publications/books/gbook/green_book_2ed.pdf

Table 2: Chemical properties of PAHs[3]

Components of PAH:	Properties: Chemical formula	Molar mass (in g/mol)	Density (in g/cm^3)
ANT/PHN	$C_{14}H_{10}$/ $C_{14}H_{10}$	178.23/ 178.23	1.23/ 1.18
BAA	$C_{18}H_{12}$	228.29	1.19
BaP	$C_{20}H_{12}$	252.31	1.24
CHR	$C_{18}H_{12}$	228.29	1.27
FLA	$C_{16}H_{10}$	202.26	1.25
FLU	$C_{13}H_{10}$	166.22	1.20
NPH	$C_{10}H_8$	128.17	1.14
PYR	$C_{16}H_{10}$	202.26	1.27

entities (e.g., atoms, molecules, ions, electrons) as there are atoms in 12 grams of pure carbon-12 (^{12}C), the isotope of carbon with atomic weight 12. This corresponds to a value of $6.02214179(30)10^{23}$ elementary entities of the substance[2]. For example, the molar mass of BAA can be calculated as follows:

$$\begin{aligned} M(C_{18}H_{12}) &= [(18 * 12.0107) + (12 * 1.00794)] * 1\ g/mol \\ &= 228.29\ g/mol \end{aligned}$$

PAHs are toxic, carcinogenic, and mutagenic to all organisms, including humans (Nacci et al., 2002 and Armstrong et al., 2004). The metabolites of PAHs may bind to proteins and DNA, which causes biochemical disruption and cell damage in animals and cancer in human (Armstrong et al., 2004). The main sources of these contaminants in the environment include forest fire, natural petroleum seeps, combustion of fossil fuels, coal burning, and use of oil for cooking and heating (Christensen and

[2]http://www.bipm.org/utils/common/pdf/si_brochure_8_en.pdf
[3]http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=122&tid=25

Bzdusek, 2005 and Moon et al., 2006). Other sources include domestic and industrial waste waters and sewage.

Dietary intake has been reported as an important route for human exposure to PAHs, except for smokers and occupationally exposed populations (Scherer et al., 2000 and Falcó et al., 2003). Pollution by persistent chemicals, i.e. chemical substances which can be transported across international boundaries through the environment far from their sources is potentially harmful to the organisms at higher trophic levels in the food chain[4]. The marine organisms like fish are able to accumulate several fold higher concentration of PAHs than the surrounding water (Law and Hellou, 1999, Vives et al., 2004 and Johnson-Restrepo et al., 2008). Fish are a major source of proteins and healthy lipids for people. Despite the human benefits of a fish diet, an issue of concern related to frequent fish consumption is the potential risk arising from exposure to toxic chemicals (Domingo et al., 2007 and Sioen et al., 2008). In 2006, a number of epidemiological studies have reported that a large portion of human cancers, such as lung and prostate cancers, are attributable to dietary sources (Ambrosini et al., 2008 and Shen et al., 2008).

Marine animals can be exposed to oil via various routes (e.g., consumption of contaminated prey, uptake via gills, direct contact with sediments) and rapidly take up PAHs present in the environment. Fish efficiently metabolize PAHs, and thus rarely contain substantial amounts of PAHs in their edible muscle (Varanasi et al., 1989).

Since PAHs are compounds in oil that can cause cancer when exposed at high doses, the United States Food and Drug Administration (FDA) tests experiments on animals to ensure safe exposure for vulnerable human populations, such as children,

[4] As one organism eats another, a food chain is formed. Each step along a food chain is known as a trophic level or feeding level. Every organism can be categorized by its trophic level. Source: `http://www.chesapeakebay.net/discover/bayecosystem/foodwebs`

Table 3: PAH levels of concern

Levels of Concern (in ng/g)	
PAH Compound	Shrimp
ANT/PHN[6]	1,846,000
BAA	1,320
BaP	132
CHR	132,000
FLA	246,000
FLU	246,000
NPH	123,000
PYR	185,000

the elderly or the already infirm[5].

In this regard, FDA established the PAH levels of concern for the Louisiana Seafood Safety Plan's tested compounds after the Deepwater Horizon oil spill occurred[5]. Table 3 shows the levels of concern of PAH compounds in shrimp. As jumping ahead of our research, our visualization of fish species will be concentrated on the white shrimp. We will explain in more detail in the Observed Data section of this chapter why we concentrate our research on white shrimp. The PAH levels of concern in shrimp were originally measured in mg/kg. But we convert them in ng/g (1 mg/kg = 1,000 ng/g) to have a similar measurement unit as in white shrimp.

But the researchers claimed an inconsistency of the FDA standard for assessing seafood safety after oil spills. Rotkin-Ellman and Solomon (2010) found that FDA's "safe levels" were not safe for vulnerable populations because they allowed up to 10,000 times too much cancer-causing PAHs contamination in Gulf seafood. For example, FDA said that 123,000 ng of NPH per gram of shrimp was safe for everyone to eat. According to Rotkin-Ellman and Solomon (2010), only 5,910 ng should have

[5] `http://gulfsource.org/methodology.html`

[6] Since the levels of concern for ANT and PHN are the same, we can combine them together.

been allowed to protect pregnant women and children who eat a lot of seafood. For comparison, Rotkin-Ellman and Solomon (2010) showed that 46,990 ng of NPH per gram of shellfish would be safe for an adult consumer.

A study carried out at Louisiana State University's Department of Oceanography and Coastal Sciences by Dr. Jim Cowan showed PAHs are causing the majority of deformities in sea creatures. Fish and other sea creatures are being exposed to PAHs, which affect both the immediate health of the fish itself and the humans' genome[7].

Gulf of Mexico fishermen, scientists, and seafood processors found disturbing numbers of mutated shrimp that they believe were caused by the Deepwater Horizon oil spill. They found the following list of deformities[8]:

- Shrimp with tumors on their heads;
- Shrimp with defects on their gills and "shells missing around their gills and head";
- Shrimp without eyes;
- Shrimp with babies still attached to them.

Figure 2 shows an eyeless shrimp, from a catch of 400 pounds of eyeless shrimp, that was caught at the height of the white shrimp season in September 2011. According to Gulf of Mexico fishermen, at least 50 % of the shrimp caught in 2011 in that period in Barataria Bay, Louisiana, a popular shrimping area that was heavily impacted by BP's oil and dispersants in 2010, were eyeless[10].

To better understand the impacts of the Deepwater Horizon oil spill on shrimp, we need to know their habitat, breeding, and feeding behaviours.

[7] `http://www.aljazeera.com/indepth/features/2012/04/201241682318260912.html`

[8] `http://www.aljazeera.com/indepth/features/2012/04/201241682318260912.html`

[9] A picture was taken by Erika Blumenfeld/Al Jazeera on `http://dahrjamail.net/gulf-seafood-deformities-alarm-scientists`

[10] `http://www.aljazeera.com/indepth/features/2012/04/201241682318260912.html`

Fig. 2: Eyeless shrimp, from a catch of 400 pounds of eyeless shrimp[9]

- DESCRIPTION: Litopenaeus setiferus, commonly known as white shrimp may reach a total length (excluding antennae) of 197 mm, with females being larger than males (Muncy, 1984). The antennae may be up to three times the length of the body, which is bluish white with a tinge of pink on the sides, and black spots. White shrimp's body color is a bluish white overall, speckled with black spots, with pink-tinged sides. The pleopods are often redder, and the uropods and telson are green. The rostrum is long and thin, with 5-11 teeth on the upper edge and 2 on the lower edge, and continues along the carapace as a dorsal carina (ridge) (Smithsonian Marine Station at Fort Pierce, 2011).

- DISTRIBUTION AND HABITAT: White shrimp are distributed along the Atlantic coast from Fire Island, New York, to Saint Lucie Inlet, Florida, usually in water less than 27 m deep. White shrimp inhabit coastal waters of the Gulf of Mexico from Ochlockronee River of Apalachee Bay, Florida, to Ciudad Campeche, Mexico (Muncy, 1984). In the Gulf of Mexico, white shrimp can be found in depths as great as 79 m. But they are most abundant in brackish wetlands with connections to shallow, coastal areas. Juveniles prefer muddy substrata rich in loose peat and sandy mud. Ideal nursery grounds for juvenile white shrimp are muddy bottom areas in waters with low to moderate salinity (Smithsonian Marine Station at Fort Pierce, 2011). White shrimp require warm water, and are unable to survive below 3^oC), with appreciable growth only occurring at temperatures over 20^oC (Muncy, 1984).

White shrimp along the southeast Atlantic coast migrate southward during autumn and early winter and then northward in late winter and early spring. For example, a major southerly migration of white shrimp from North Carolina to Cape Canaveral, Florida, in fall and a northerly migration from the Cape in spring were noted in Muncy (1984).

- BREEDING: White shrimp spawn when offshore bottom water temperatures increase, generally from May through September in the Carolinas and from March through September further south in the Gulf of Mexico. Spawning in white shrimp generally occurs within 9 km of the shoreline, in water less than 9 m deep in the Atlantic, or 8-31 m deep in the Gulf of Mexico. Males attach a spermatophore to the females, which is then used to fertilize the eggs as they are released. Each female releases 500,000-1,000,000 purplish eggs, each 0.2-0.3 mm across, which sink to the bottom of the water column (Muncy, 1984).

  "After 10-12 hours, the eggs hatch into nauplius larvae, which are 0.3 mm long, planktonic and unable to feed. They molt five times to reach the protozoea stage, 1 mm long. These grow to 2.5 mm long over two molts, before passing through three molts as a mysis larva. About 15-20 days after hatching, the animals reaches the postlarva stage; in the second postlarval stage, at a length of 7 mm, they begin to enter estuaries and drop down to the substrate" (Muncy, 1984).

- FEEDING: "White shrimp larvae feed on plankton (tiny plants and animals). Juvenile and adult shrimp are omnivorous and feed on the bottom on detritus, plants, microorganisms, macroinvertebrates, and small fish. Cannibalism is also common among adult white shrimp. Sheepshead minnows, water boatmen, and insect larvae eat postlarval shrimp; grass shrimp, killifishes, and blue crabs prey on young shrimp; and a wide variety of finfish feed heavily on juvenile and adult shrimp"[11].

Moreover, Muncy (1984) lists a few environmental conditions that are required for white shrimp development:

- Temperature: "Water temperature directly or indirectly influences white shrimp spawning, growth, habitat selection, osmoregulation, movement, migration, and mortality. Spring water temperature increases trigger spawning, and rapid water temperature declines in fall portend the end of spawning. Growth is fastest in summer and slow or negligible in winter" (Muncy, 1984).

- Salinity: "Adult white shrimp spawn offshore where salinities are at least 27 ppt[12]. Although field studies indicate that juvenile white shrimp prefer low salinities, laboratory studies have revealed that white shrimp appear to tolerate a wide range of salinities; they have been successfully reared at salinities of 18 to 34 ppt" (Muncy, 1984).

Muncy (1984) also indicates that the tolerance ranges of white shrimp to temperature-salinity interactions vary at their different life stages. For example, the broken-back syndrome (dorsal separation of thrid and fourth pleural plates on abdominal) appears after sudden drops in salinity (from 15 ppt to 3 ppt) in cold water (8^oC). Freshwater

[11] `http://www.fishwatch.gov/seafood_profiles/species/shrimp/species_pages/white_shrimp.htm`

[12] parts per thousand

inflow may affect coastal water temperatures, which in turn affect the growth migration of white shrimp. Spring spawning of white shrimp coincides with a rapid rise in bottom water temperatures in high salinity offshore waters.

For other environmental conditions, Muncy (1984) highlights the loss of nursery grounds (landfill, dredging, and impoundments) has been considered the major threat to the white shrimp fishery in the Gulf of Mexico because that is where shrimp are most vulnerable to habitat disturbance.

Table 4: Fish2005 data summary

Fish Species	Obser-vations	Areas	Number of Sites / Locations	Months	Toxicities (in ng/g)
Atlantic croaker	20	Mississippi Delta	7	September - October	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Blue crab	4	Lake Borgne	2	September	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
White shrimp	88	Lake Borgne, Mississippi Sound, Mobile Bay	26	September - December	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR

2.2 Observed Data

Fish-baseline data, one of the two available fish data sets, were collected by NOAA and posted on `http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-baseline.csv`. Since the data combine the fish observations in the Gulf of Mexico for 2005 and 2006, we split them into two data sets, namely **Fish2005** and **Fish2006**. The data reading R code can be found in Appendix B.2.1.

Fish2005 and Fish2006 consist of fish species, the number of observations, areas, the number of sites/ locations, months of the year, and toxicity concentrations variables (see Tables 4 and 5).

The second fish data set, *fish-june2010 data* is available on `http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-june2010.csv`. We further refer to it as **Fish2010**. Fish2010 consists of fish species, the number of observations, areas, the number of sites/ locations, months, and toxicity concentrations

Table 5: Fish2006 data summary

Fish Species	Observations	Areas	Number of Sites / Locations	Months	Toxicities (in ng/g)
Atlantic croaker	35	Mississippi Delta, West of Mississippi Delta	12	November	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
White shrimp	72	Lake Borgne, Mississippi Delta, Mississippi Sound, Mobile Bay, West of Missisippi Delta	38	April, May, July, September, November, December	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR

variables (see Table 6).

Compared to the Fish2005 and Fish2006 data, the Fish2010 data consist of missing (*NA*) observations, left-censored data (such as "< ..." for several toxicities), and meta information (such as sentences at the beginning and at the end of data file). Thus, we have to clean the data first from these problems in R. The challenging part of the data cleaning was to read the toxicity values with less signs ("<") into R. The software R deals only with numerical values to complete some statistical analyses. One option would have been deleting these less signs, but we also would have lost a crucial information in that case. So, we deleted less signs from the toxicity values and added new columns at the end of data with "0" for the values with less signs and "1" for the values without less signs for each corresponding PAHs' components. R code for data cleaning can be found in Appendix B.2.2.

The Fish2010 data contains that the concentrations of selected PAHs measured in ng/g (wet weight) in edible[13] tissues of oysters, shrimp, and fish collected in the

[13] According to the methodology of Seafood Sample Collection and Handling of the Gulfsource cited on `http://gulfsource.org/methodology.html`, each sample species contains approximately a half-pound of edible flesh.

Table 6: Fish2010 data summary

Fish Species	Observations	Areas	Number of Sites / Locations	Months	Toxicities (in ng/g)
Atlantic oyster	14	Mississippi Sound	5	April, May	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Brown shrimp	4	Mississippi Sound, North Central Gulf	4	May	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Gag grouper	1	North Central Gulf	1	April	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Gray trigger fish	1	North Central Gulf	1	May	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Red drum	3	North Central Gulf	3	April, May	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Red snapper	10	North Central Gulf	10	April, May	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Vermillion snapper	1	North Central Gulf	1	May	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
Warsaw grouper	1	North Central Gulf	1	April	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR
White shrimp	10	North Central Gulf, Mississippi Sound	9	April, May	NPH, FLU, ANT/PHN, FLA, CHR, BaP, BAA and PYR

Gulf of Mexico region as part of the Deepwater Horizon MC Canyon 252- Seafood Safety Response 2010.

In our study, we will also frequently refer to the satellite derived surface oil areas in the Gulf of Mexico. The surface oil spill areas were measured and recorded by the NOAA Satellite and Information Service. The NOAA provided the periodically recorded daily remote sensing data from April 22, 2010, until August 25, 2010. The data can be found on `http://www.ssd.noaa.gov/PS/MPS/deepwater.html`.

Table 7: The collection days of April and May of 2006 and 2010

Fish2006		Fish2010	
Date	Number of Observations	Date	Number of Observations
4/11/2006	1	4/30/2010	6
4/12/2006	3	5/1/2010	1
4/13/2006	3	5/2/2010	1
4/14/2006	6	5/6/2010	1
4/15/2006	3	5/7/2010	1
5/9/2006	4		
5/10/2006	1		
5/11/2006	3		
5/12/2006	3		
5/13/2006	3		
5/14/2006	1		
Total	31	Total	10

2.3 Results

In this section, we take a closer look at the PAHs concentrations in fish species before and after the oil spill in order to see the impact of the oil spill on the Gulf fish.

Tables 4, 5 and 6 show the white shrimp are the only common fish species which were collected in all these years, i.e. in 2005, 2006, and 2010. We can also notice that Fish2006 and Fish2010 have the same months of white shrimp collection periods, i.e., April and May. Table 7 shows the collection days of April and May of 2006 and 2010.

Figure 3 shows the components of polycyclic aromatic hydrocarbons (PAHs) in the white shrimp observed in 2005, 2006 and 2010. The observations collected in April and May of 2006 and 2010 are indicated by the blue color symbols: the plus

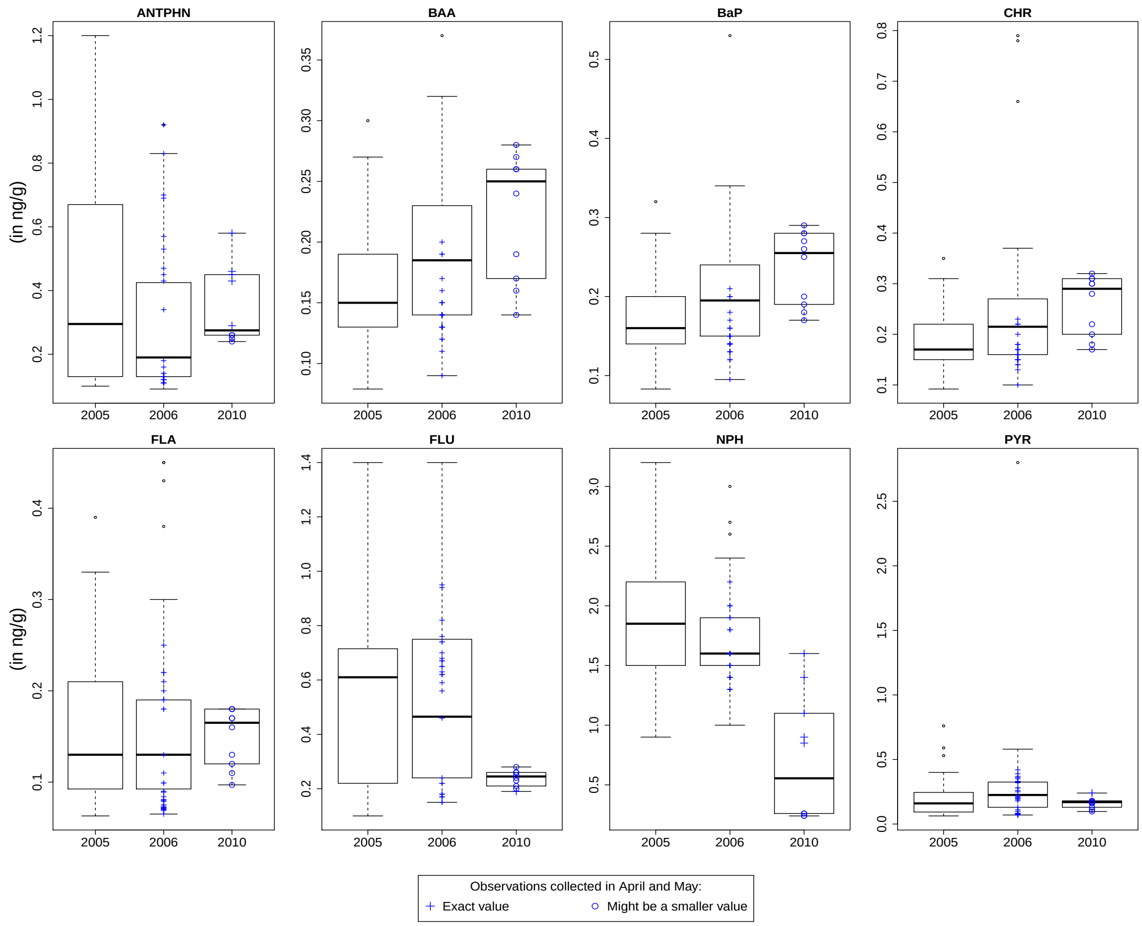


Fig. 3: The toxicity levels of white shrimp in 2005, 2006 and 2010

Table 8: The extreme outliers in PAHs components

PAHs Components	Number of Outliers	Toxicity Value
CHR	3	0.66, 0.78 and 0.79
BaP	1	0.53
PYR	1	2.8

("+") signs represent exact observed toxicity values while the blue circles ("∘") might have lower toxicity levels, because of the left-censoring in 2010. R code for Figure 3 can be found in Appendix B.2.3.

The medians of the toxicity concentrations in the observed white shrimp of 2005 and 2006 are higher than the medians of observed concentrations in 2010 only for NPH and FLU. The medians of toxicity concentrations of BAA, BaP, CHR, and FLA in 2010 are higher than the medians in 2005 and 2006.

We can also notice a few potential outliers for the CHR, BaP, and PYR toxicity components from Figure 3. These outliers belong to the Fish2006 data and are considerably deviated from the rest of the sample (see Table 8). Thus, we removed the following outliers from further analyses:

We draw a heatmap (see Figure 4) to see the correlations between dates / locations and toxicity levels of the observed white shrimp in 2005, 2006, and 2010. The heatmap in Figure 4 has been produced by function *heatmap.2* of package *gplots* (Warnes et al., 2012). R code for Figure 4 can be found in Appendix B.2.4.

A heat map is a graphical representation of data where the individual values contained in a matrix are represented as colors. Heat Maps originated in 2D displays of the values in a data matrix. Values are usually symbolized by colours. Larger values

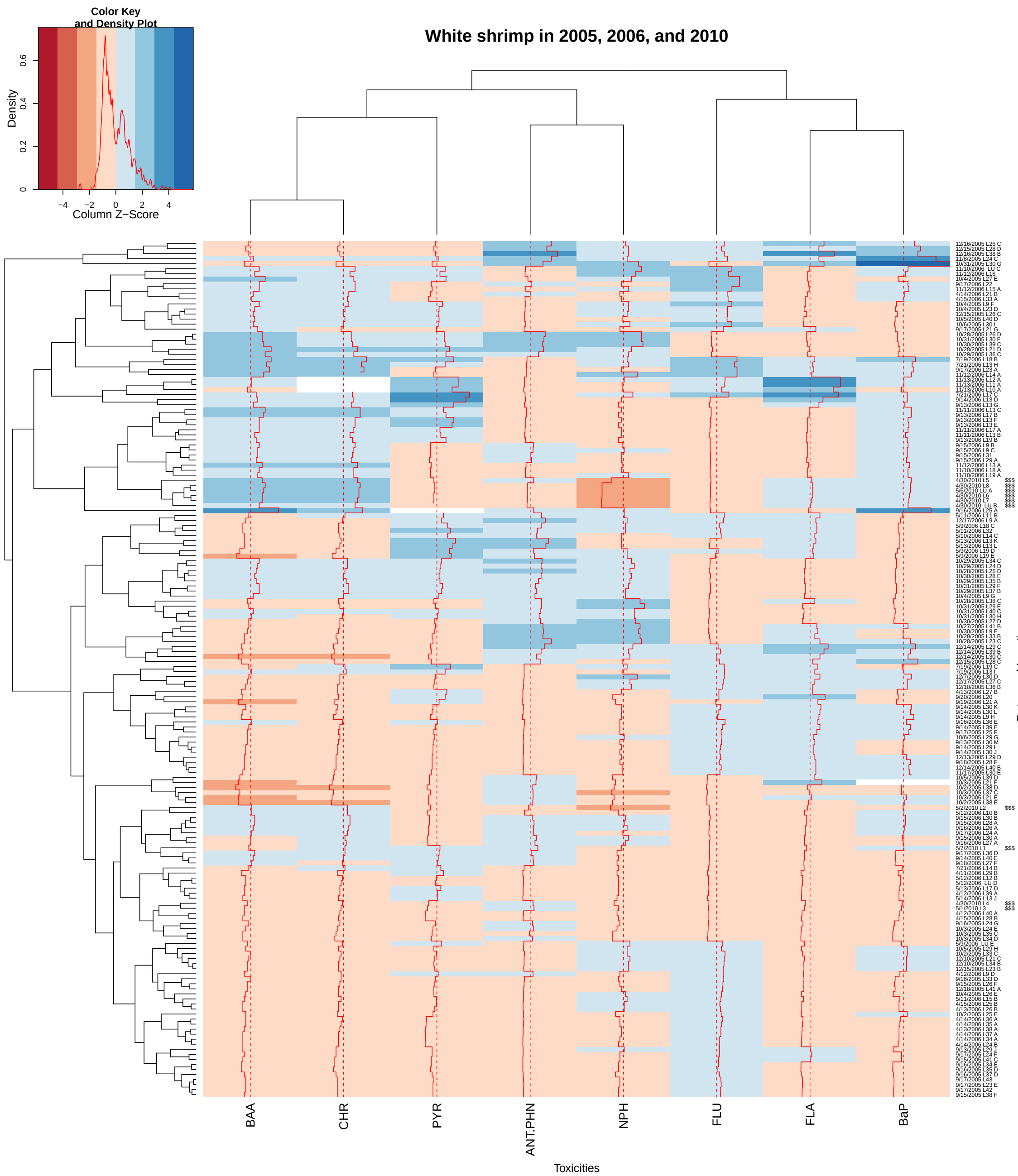


Fig. 4: The heatmap of white shrimp toxicities of 2005, 2006, and 2010. The white shrimp of 2010 are highlighted with “$$$” at the end of temporal and spatial locations. The red dashed lines show the average toxicity of PAHs components whereas the red solid lines show the toxicity deviations from the average within temporal and spatial locations.

were represented by darker squares (pixels) and smaller values by lighter squares[14].

The heatmap (see Figure 4) shows the deviations of toxicities from the mean of toxicity column for each individual observation. There is a total of 170 observations that were collected from different or the same locations during 2005, 2006, and 2010.

The observations are denoted according to their observed locations and dates. For example, there are two observations which were collected on different dates (11/13/2006 and 5/11/2006) from the same location in the Gulf of Mexico. We denote them “11/13/2006 L11 A” and “5/11/2006 L11 B”, respectively. The “L11” is denoted for the location of these observations whereas the letters “A” and “B” represent the number of observations. We use a character “LU” for the observations with undefined locations. We also highlight the locations and observations collected in 2010 with “$$$” at the end. For example, the observation collected on 5/7/2010 is denoted by “5/7/2010 L1 $$$”.

The heatmap normalizes (scales) the toxicity levels of white shrimp to SD (Standard Deviation) units by using the following formula:

$$z = \frac{Value - Mean}{SD}$$

The normalization is shown as the column z-score in the Color Key and Density Plot in Figure 4. The toxicity levels range from -4 to 4 standard units.

The deviations of toxicities from the average toxicity of a group[15] within the observed dates and locations are displayed by fluctuations of red solid line from the red dashed lines. Larger deviations are displayed by darker colors, where red represents smaller toxicity levels and blue represents larger toxicity levels.

[14] `http://www.reference.com/browse/Heat_map`

[15] For example, the NPH of 2005, 2006, and 2010 is one toxicity group

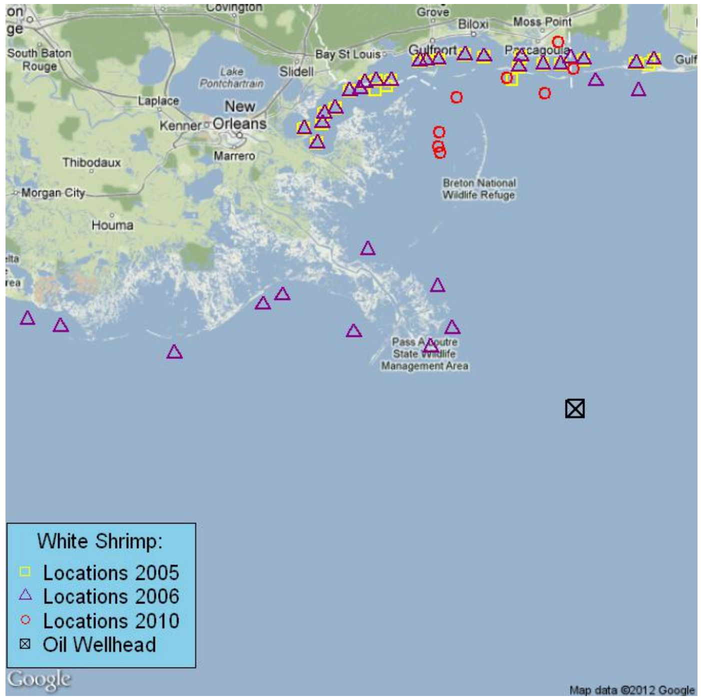


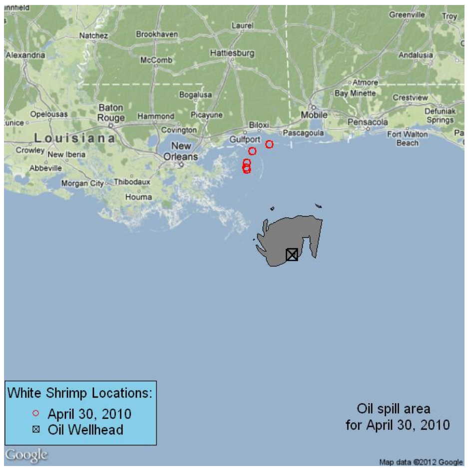
Fig. 5: The white shrimp locations observed in 2005, 2006, and 2010

Figure 5 displays the locations of the observed white shrimp in 2005, 2006 and 2010, as well as the oil spill location in 2010.

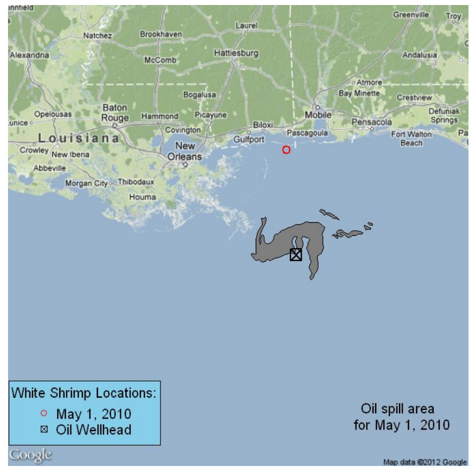
Figure 6 shows in more detail the locations of the observed white shrimp in 2010 and the surface oil spill areas for the period from April 30, 2010 to May 8, 2012. R code for Figure 6 can be found in Appendix B.2.5.

We can also see the spatial locations and the concentrations of PAHs components in the white shrimp within observational months of 2005, 2006, and 2010. Figure 7 shows how NPH concentrations in the white shrimp changed from April to December of the three years.

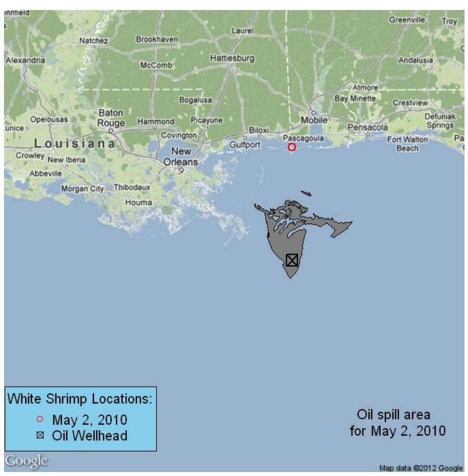
Figures 7(a) and 7(b) present the NPH levels of white shrimp in April and May of 2006 and 2010, as well as the surface oil spill areas. The white shrimp were not observed in these months of 2005. The surface oil spill area for April (see Figure 7(a)) was measured on the last day of the month, April 30, 2010, whereas the oil spill



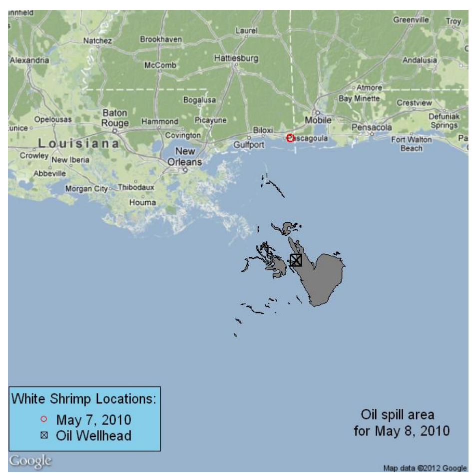
(a) April 30, 2010



(b) May 1, 2010

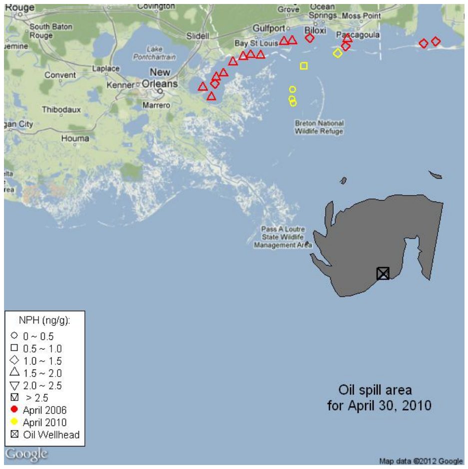


(c) May 2, 2010

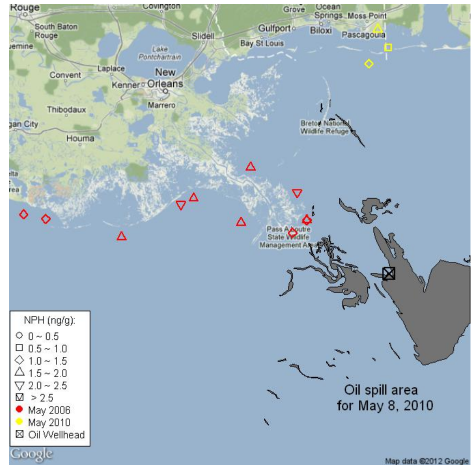


(d) May 7, 2010

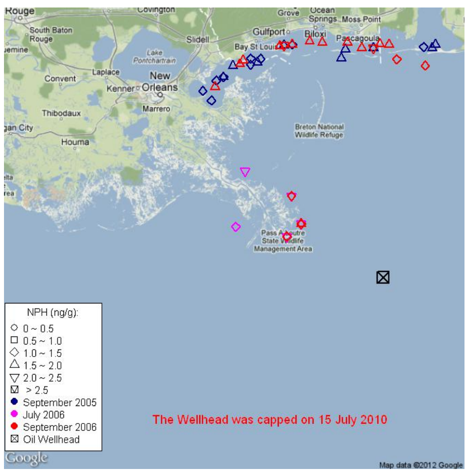
Fig. 6: The observed white shrimp and oil spill areas of 2010



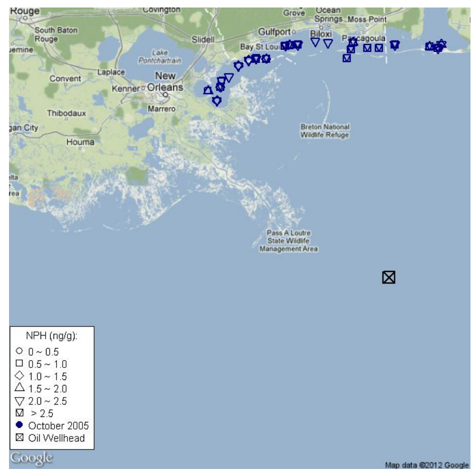
(a) April



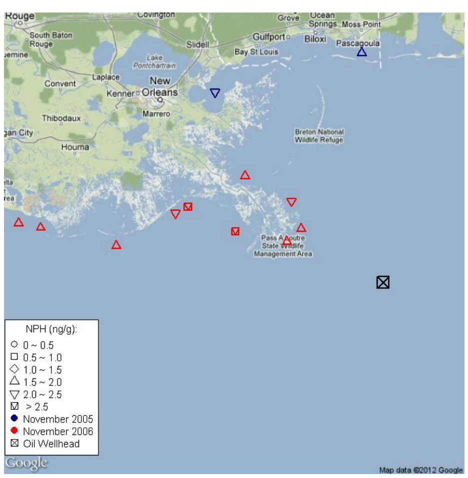
(b) May



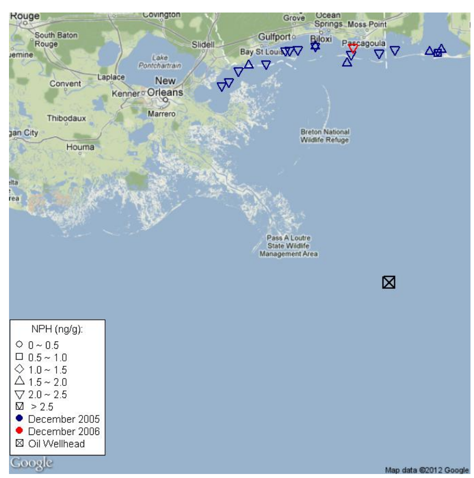
(c) July and September



(d) October



(e) November



(f) December

Fig. 7: NPH concentration level in white shrimp in 2005, 2006, and 2010

area for May (see Figure 7(b)) was obtained on May 8, 2010, a day after the last white shrimp was observed in 2010[16]. Since the white shrimp in 2010 were observed only in April and May (see Table 7), the remaining plots in Figure 7 display only the observations in 2005 and 2006. The white shrimp were not collected in July 2005 (see Figure 7(c)) and in October 2006 (see Figure 7(d)).

The visualization of the other PAHs components are displayed in Figures 42, 37, 41, 39, 38, 40, and 43. These figures can be found in Appendix A.1.1. Appendix B.2.6 contains R code for the PAHs components' figures.

Moreover, we examined the relationships among the PAHs components which were observed in the white shrimp in 2005, 2006 and 2010. The scatterplot matrix in Figure 8 displays all pairwise scatterplots of PAHs components.

All PAHs components of white shrimp in 2005, 2006, and 2010 are combined in their respective toxicity groups. Thus, the scatterplot matrix which was plotted by using the package *car* (Fox and Weisberg, 2011) of R shows the relationship between NPH for 2005, 2006, and 2010 and FLU for 2005, 2006, and 2010, and so on. R code for the scatterplot matrix can be found in Appendix B.2.7.

[16] The surface oil spill area for May 7, 2010 is not available.

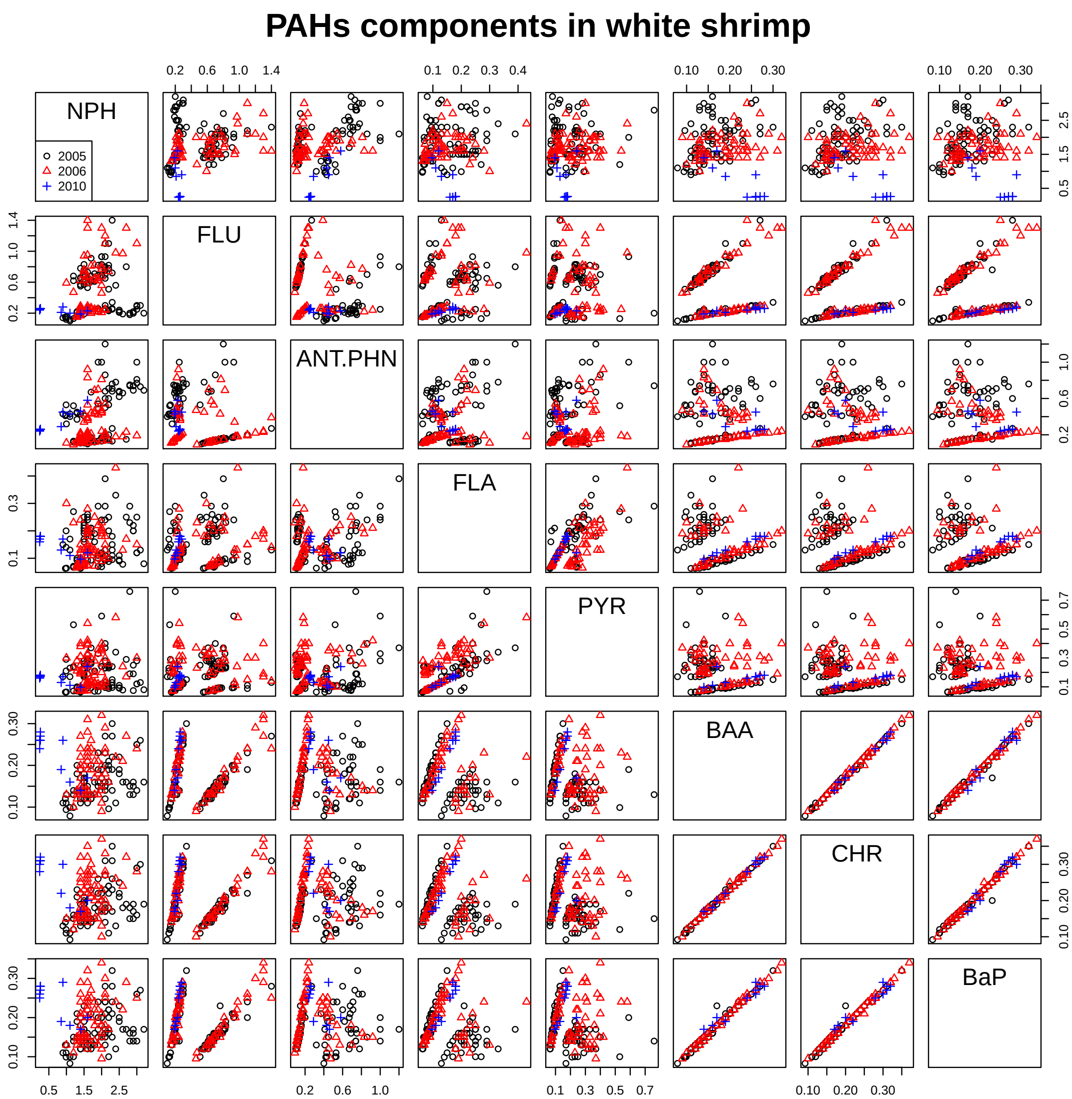


Fig. 8: The scatterplot matrix of PAHs components of white shrimp

2.4 Discussions

The boxplots in Figure 3 display the range of the observed toxicity levels in white shrimp collected in 2005, 2006, and 2010. The boxplots show that the white shrimp of 2010 had higher medians of toxicity concentrations only in BAA, BaP and CHR than the medians for these toxicities in 2005 and 2006. Similarly, the white shrimp collected in April and May of 2010, represented by the blue symbols, had higher concentrations in BAA, BaP and CHR than the white shrimp from the same period of 2006. However, the blue circles on the boxplots of BAA, BaP and CHR for 2010 indicate that the toxicity levels might actually be smaller values than what is shown in the boxplots.

Another finding from Figure 3 is that the components of PAHs in white shrimp were well below the FDA regulatory limits for seafood. For example, the highest toxicity level of ANT/PHN was observed in 2005 and was 1.2 ng/g which is hundred thousand times smaller than 1,846,000 ng/g, the safety level of ANT/PNH in shrimp (see Table 3). However, the researchers question the consistency of the PAHs' levels of concern with the safety of seafood consumption by children, pregnant women and other vulnerable populations (Rotkin-Ellman and Solomon, 2010). Rotkin-Ellman and Solomon (2010) showed that the lower toxicity levels than the PAHs' levels of concern in fish species from the areas where the oil spill occurred might be very harmful for consumers.

The heatmap in Figure 4 also shows that the higher BAA, CHR, and BaP concentrations were observed during the post-disaster period, i.e., in April and May of 2010. For that period of time, BAA and CHR are clustered together and positively deviated approximately two SD above the mean of these toxicity groups, whereas BaP is deviated approximately one SD above the mean. We can also notice that NPH had a lower concentration for that period of time. They are negatively deviated for more than two SD below the NPH mean. These findings belong to the white shrimp locations from L5 to L8 and in two unknown locations (LU A and LU B) mostly on April 30, 2010 and one location on May 6, 2010. The lower concentrations of BAA and CHR for 2010 were noticed in only one location, 5/2/2010 L2.

The boxplots and the heatmap lead to the conclusion that the toxicity concentrations in 2010 were not highly different from those which were collected in 2005 and 2006. Thus, the available data for fish, in particular white shrimp, does not allow drawing the conclusion that the oil spill had any negative impact on white shrimp in 2010. Far more data (and not just 10 observations) would be needed to possibly come up with a different conclusion.

The spatial locations of the observed white shrimp of 2005, 2006, and 2010 are shown in Figure 5. We can see the white shrimp of 2005 and 2010 were mainly collected in the North Central Gulf of Mexico whereas the white shrimp of 2006 were collected all through the Mississippi Delta of the Gulf of Mexico. Figure 5 shows that only a few observations of 2005, 2006, and 2010 had overlapping locations close to the town of Pascagoula, North Central Gulf of Mexico. We can also notice that the locations of observations in 2010 were far away from the Deepwater Horizon oil spill location. Figure 6 displays the locations of the white shrimp collected in April and May of 2010 with respect to the surface oil spill area change for that period of time. We can see that the locations of the white shrimp were far away from the oil spill wellhead and areas of oil-polluted water. We may conclude from Figures 5 and 6 that there is no explicit negative impact from the oil spill on the white shrimp as the oil had not yet reached the areas where the white shrimp were collected in April and May 2010.

The scatterplot matrix in Figure 8 contains all the pairwise scatterplots of PAHs components which were observed in white shrimp in 2005, 2006, and 2010. The scatterplot matrix displays that BAA, CHR, and BaP have very strong pairwise correlations. This might occur because these PAHs components have approximately similar chemical properties. Table 2 shows that BAA and CHR have the same molecular formula and molar mass. BaP has the same number of hydrogen atoms ($C_{20}H_{12}$) as the number of hydrogen atoms of BAA and CHR. The similarity of chemical properties of BAA, CHR, and BaP may result in similar patterns of clustering of observations with the rest of the PAHs.

However, the similarity of chemical properties may not be a sufficient explanation of the strong correlations. Though FLA and PYR have the same chemical compositions and molar mass (see Table 2), they don't have a strong relationship in Figure 8. We can also notice that two positively associated groups of the observations are created by the relationships FLU vs BAA/CHR/BaP and FLA vs BAA/CHR/BaP. In order to understand clearly the reason behind these relationships, we may need a deeper knowledge in chemistry. The rest of the PAHs components have a weak positive association.

Figure 8 also shows that the NPH concentrations in the white shrimp of 2010 were considerably lower than the observed concentrations in 2005 and 2006, matching the boxplot in Figure 3.

As an overall conclusion, our observational data for white shrimp for 2005, 2006, and 2010 are not very helpful to make a judgement on the negative impact of the oil spill on fish species. The observed locations of the white shrimp for the post-disaster period, April and May 2010, were far away from the oil spill wellhead and surface oil areas. The available Fish2010 data do not allow us to carry out a complete statistical analysis, as the left-censored toxicity concentrations leave space for further discussion.

Though our fish data do not explicitly show the anticipated negative effects of the oil spill on the fish species, we have to consider confounding factors that likely effected the observational study. One potential confounding factor, for example, might be temperature and salinity changes after the mixture of oil with water. Lee and Marcovitz (2011) asserts that the oil spill in the Gulf of Mexico was behind the reduction of the salinity of the ocean water and the temperature change in the Gulf: a cool fall followed by a warm winter.

CHAPTER 3
BIRDS

3.1 General Background

"The Gulf of Mexico hosts a large number of bird species. Many live there year round, while some migrate to this warm location during the winter. Species include native birds such as pelicans, anhingas, frigatebirds, egrets, herons, spoonbills, ibis, and mallard ducks, and wintering species which include the large northern gannet"[1].

The April explosion on the Deepwater Horizon oil wellhead and subsequent oil leak that followed has caused some major damage to the coast and wildlife of the Gulf of Mexico. Particularly, the spill has affected thousands of birds and destroyed their habitat for a long term. United States Fish and Wildlife Service (2011) shows that the number of observed dead birds in 2011 was similar to the number of dead birds in 2010. Dead animals are still washing up on beaches. The researchers are warning that some of the consequences of the spill may not be known for decades.

3.1.1 Birds Affected by Oil Spills

"The birds most affected by oil spills and petroleum contamination are those that spend a majority of their time at sea or near the water, such as gulls, ducks, pelicans, auks, grebes, terns, and loons. If the oil reaches shore, however, all types of shorebirds may be affected, as well as migratory songbirds that use polluted habitats as critical migration stopovers. Birds that feed from polluted areas, such as fish-hunting eagles and ospreys, can also feel the disastrous effects of oil spills. In short, no bird species

[1] `http://marinelife.about.com/od/habitatprofiles/tp/GulfofMexicoMarineLife.htm`

are entirely unaffected by this type of toxic pollution"[2].

3.1.2 How Oil Affects Birds

"The most obvious way oil affects birds is by coating their plumage in sticky, greasy slime. Birds' feathers are precisely aligned and designed to provide superb waterproofing and insulation. Oil in the feathers, however, will mat them and misalign the tiny barbs that keep the feathers properly positioned, and even a small misalignment can cause birds to lose critical body heat, therefore exposing them to temperatures and weather conditions that can be fatal. Oiled birds also lose their natural buoyancy from air pockets created by proper feather alignment, and they can sink and drown in polluted waters.

In order to remove the oil from their feathers, oiled birds will begin to preen excessively, even desperately. As they preen, they inadvertently ingest the toxic sludge, which will then poison their kidneys, liver, lungs, intestines and other internal organs, causing slow and agonizing death. If they do not die from the oil's toxicity, their excessive preening in a desperate attempt to realign their feathers and get clean again will cost them more energy than they can spare, and many oiled birds eventually succumb to exhaustion, dehydration, or starvation"[3].

Figure 9(a) shows a laughing gull languished in surf tainted by the Deepwater Horizon oil spill on East Grand Terre Island, Louisiana, on June 4. Figure 9(b) also shows that shouldering the weight of heavy oil spewed from the Gulf of Mexico's Deepwater Horizon oil spill, a brown pelican struggles in sludgy surf on East Grand Terre Island, Louisiana.

[2] http://www.amsa.gov.au/marine_environment_protection/educational_resources_and_information/teachers/the_effects_of_oil_on_wildlife.asp

[3] http://birding.about.com/od/birdconservation/a/oilaffectsbirds.htm

[4] http://news.nationalgeographic.com/news/2010/06/photogalleries/100608-gulf-oil-spill-environment-birds-animals-pictures

(a) Laughing gull (b) Brown pelican

Fig. 9: Birds affected by the Deepwater Horizon oil spill[4]

In sum, the oil spill can affect birds in the following way:

- "hypothermia in birds by reducing or destroying the insulation and waterproofing properties of their feathers;
- birds become easy prey, as their feathers being matted by oil make them less able to fly away;
- birds sink or drown because oiled feathers weigh more and their sticky feathers cannot trap enough air between them to keep them buoyant;
- birds lose body weight as their metabolism tries to combat low body temperature;
- birds become dehydrated and can starve as they give up or reduce drinking, diving, and swimming to look for food;
- damage to the birds bodies, for example by causing ulcers or bleeding in their stomachs if they ingest the oil by accident"[5].

[5] http://www.amsa.gov.au/marine_environment_protection/educational_resources_and_information/teachers/the_effects_of_oil_on_wildlife.asp

3.1.3 Additional Impacts of Oil on Birds

"Oil has additional impacts on birds than just coating their plumage. An area subjected to a large oil spill may become uninhabitable for the birds as food supplies are gradually killed off from the toxic poisons, and oil coating nesting areas may destroy critical habitat. If birds are already nesting at the time of the pollution, oil that coats the eggs will suffocate the unhatched chicks, decimating the birds' population. If eggs have not been laid but female adults ingest the oil, the pollution can cause thinner shells that are more subject to being crushed and causing malformed chicks that will not survive. Over time, small amounts of oil in the birds' ecosystem can be absorbed into food supplies, gradually building to deadly concentrations in birds that eat that food, whether it is plant life, insects, fish, or other food sources"[6].

3.1.4 Mostly Affected Bird Species

According to the National Wildlife Federation (NWF), laughing gull, brown pelican and northern gannet were top bird species harshly affected by the oil spill[7]. Laughing gull belongs to the Charadriiformes biological order, while brown pelican and northern gannet are in the Pelecaniformes biological order.

3.1.4.1 Charadriiformes Biological Order

Charadriiformes includes about 350 species of birds. They are found in all parts of the world. The birds in this order live near or on the water and eat invertebrates or other small animals and they range in size from small to large (Fain and Houde, 2004).

[6] `http://birding.about.com/od/birdconservation/a/oilaffectsbirds.htm`
[7] `http://www.nwf.org/Oil-Spill/Effects-on-Wildlife/Birds.aspx`

Fig. 10: Laughing gull[8]

Laughing Gull

- DESCRIPTION: "Laughing gulls are easy to identify (see Figure 10). They are 36-41 cm long with a 98-110 cm wingspan. The summer adult's body is white apart from the dark grey back and wings and black head. Its wings are much darker grey than all other gulls of similar size except the smaller Franklin's Gull, and they have black tips without the white crescent shown by Franklin's. The beak is long and red. The black hood is mostly lost in winter.

  Laughing gulls take three years to reach adult plumage. Immature birds are always darker than most similar-sized gulls other than Franklin's. First-year birds are greyer below and have paler heads than first-year Franklin's, and second-years can be distinguished by the wing pattern and structure"[9].

- DISTRIBUTION AND HABITAT: "The Laughing gull is a medium-sized gull of North and South America. Laughing gulls winter regularly in Virginia, and a

[8] http://upload.wikimedia.org/wikipedia/commons/4/44/Laughing_gull_St_Thomas.JPG
[9] http://en.wikipedia.org/wiki/Laughing_Gull

few can be found even further north. Northernmost populations migrate further south in winter, and this species occurs as a rare vagrant to western Europe"[9]. They like marshes, bays, and estuaries – the very habitat being destroyed by the Deepwater Horizon oil spill. During the winter months, they look for food in harbors and along beaches.

Laughing gulls are a coastal species and are only occasionally seen very far inland. They nest, often in large numbers, on islands near the shore but safely isolated from terrestrial predators.

- BREEDING: "Laughing gulls breed along the eastern seaboard of the U.S. from the Gulf of Mexico to Connecticut with breeding areas also found in Massachusetts and Maine. In the winter, the species can be found nesting south of Virginia"[10]. "The breeding season begins in early April and extends into July. Laughing gulls nest in colonies, which can be very large. The nest is common in coastal areas on the ground or within the beach grasses. The female lays 2-4 (usually 3) eggs that both adults incubate for 21-23 days. The young are semi-precocial and leave the nest within a few days of hatching. The adults tend to the young for approximately 35 days after hatching"[11].

- FEEDING: Laughing gulls feed either aerially or from the water's surface by diving or skimming. The laughing gull seldom strays far from the coast. The diet is highly varied and typical items include small fish, garbage, sewage, refuse from fishing boats, and insects[12].

[10] http://www.pwrc.usgs.gov/bioeco/lgull.htm

[11] http://dromus.nhm.uga.edu/~gmnh/gawildlife/index.php?page=speciespages/species_page&key=latricilla

[12] http://www.pwrc.usgs.gov/bioeco/lgull.htm

3.1.4.2 Pelecaniformes Biological Order

Pelecaniformes is an order of medium-sized and large waterbirds found worldwide. Tropic-birds, pelicans, boobies, cormorants, and frigate birds are all members of this group, comprised of about fifty species. Pelecaniformes can be distinguished by their toes, all four of which are webbed and point forward. Also, the chicks of this order are, for the most part, hatched naked and are thus extremely dependent on their parents. Additionally, the nostrils of these birds are often sealed or otherwise protected as an adaptation for diving, a common means of hunting in this order.

Pelecaniformes inhabit the shores of oceans and seas and the banks of large rivers and lakes over almost all the terrestrial globe, except for the polar regions. Pelecaniformes birds feed mainly on fish. Cormorants and anhingas are excellent swimmers and divers; gannets and tropic birds dive, throwing themselves into the water from flight (they swim reluctantly); pelicans swim well but cannot dive. Pelicans, frigate birds, and gannets are capable of soaring. Most of the birds in this order move poorly on the ground. Their nests are usually near the water (cormorants' nests are on trees and rocks; pelicans' nests are on reed-overgrown banks). They nest in large colonies. Both females and males sit on the eggs. The fledglings are hatched blind and naked, and they grow slowly. On some tropical islands where there are colonies of Pelecaniformes, deposits of guano are formed[13].

Let's look at the feeding and breeding behaviors of brown pelican and northern gannet in more detail.

Brown Pelican

According to USFWS, the brown pelican is the bird species hit hardest by the Deepwater Horizon oil spill: 58 percent of all dead or injured birds collected from

[13] http://encyclopedia2.thefreedictionary.com/Pelecaniformes

Fig. 11: Brown pelican[15]

the period when the oil spill started until mid-July of 2010 have been pelicans. The explosion of the oil wellhead in April, when pelicans were at the start of their annual nesting season, affected brown pelicans very badly[14].

- DESCRIPTION: "Brown pelicans are large (3-5 kg), mostly dark brown birds with white to pale yellow necks, and black feet and legs. Their most distinguishing feature is a long beak (23-34 cm) with a hooked tip and a huge pouch. Their legs are short and all four toes are webbed. Their wing span is more than two meters, they soar well, and often glide low over the water. The sexes are alike"[16].

- DISTRIBUTION AND HABITAT: "Brown pelicans breed from Anacapa Island, California south to Chile and from Maryland to Venezuela and Trinidad. After breeding, they may be seen as far north as British Columbia and Nova

[14] http://www.nwf.org/News-and-Magazines/National-Wildlife/Birds/Archives/2010/Pelicans-Oil.aspx

[15] http://www.celsias.com/media/uploads/admin/brown_pelican390.jpg

[16] http://nationalzoo.si.edu/Animals/Birds/Facts/FactSheets/fact-brownpelican.cfm

Scotia. They are the only species of pelican that is strictly marine in habitat, never found more than 20 miles out to sea or inland on fresh water. They prefer shallow inshore waters such as estuaries and bays”[16].

- FEEDING: “Brown pelicans feed on mid-sized fish that they capture by diving from above and then scooping or dipping the fish into their pouch, which acts as a flexible dip net. Although they do feed on anchovies and sardines, most of their prey has little commercial value. They are the only species of pelican that hunts with such dramatic plunging dives. After capturing the fish they rise to the surface and drain the water from the pouch. They point the bill up and swallow the catch. They are often robbed of their catch by gulls before they get the chance to swallow. Juvenile brown pelicans have been observed fishing in the manner of the other pelican species, by swimming on the surface of the water. The pelican’s beak can “really hold more than its belly can”. The pouch holds about three gallons, the stomach about one gallon. They also take some invertebrates. They are a familiar sight around fishing ports within their range, where they roost on piers, docks, and fishing boats feeding on scraps”[16].

- BREEDING: Nesting is on islands by preference. On the southeast coast, it is often in mangroves, where the birds build a rather flimsy nest of sticks, reeds, bones, and seaweed. On islands without predators, they often build on the ground. They nest in colonies, and are sensitive to disturbance by tourists and fisherman while breeding. As pelican nesting peaks during March and April, they usually lay two or three eggs. Incubation lasts 28 to 30 days. Young pelicans start to walk independently at about 35 days after hatching from a ground nest, but do not leave treetop nests for up to 68-88 days. In the 8-10

Fig. 12: Northern gannet[18]

month period they are cared for, the nestling pelicans eat around 70 kg of fish. Sexual maturity is reached after two to five years[16].

Northern Gannet

Another bird species of the Pelecaniformes biological order that suffered the most from the Deepwater Horizon oil spill was the northern gannet. Though most adult gannets had already made their migration north, away from the Gulf, in April before the oil spill began, more than 50,000 juvenile gannets were in the Gulf at the time and suffered oil-related mortality. Due to the migrating behaviour of the northern gannet, it is impossible to clearly estimate the oil spill damage to this species[17].

- DESCRIPTION: "Young birds are dark brown in their first year, and gradually acquire more white in subsequent seasons until they reach maturity after five years. Adults are 81-110 cm long, weigh 2.2-3.6 kg, and have a 165-180 cm

[17] http://letfreedomrain.blogspot.com/2011/10/canadian-birds-most-adversely-affected.html

[18] http://naturecanadablog.blogspot.com/2010/08/canadas-birds-feel-impact-of-bp-oil.html

wingspan. Before fledging, the immature birds (at about 10 weeks of age) can weigh more than 4 kg. Their plumage is white with black wing tips. The bill is light bluish. The eye is light blue, and it is surrounded by bare, black skin. During breeding, the head and neck are brushed in a delicate yellow"(Mowbray, 2002).

- DISTRIBUTION AND HABITAT: Northern gannets are migratory and most winter at sea, heading further south in the Atlantic. Northern gannets in the Gulf of Mexico make usually their migration to the North in March - April and their fall migration back to the Gulf occurs in October.

  There are six northern gannet colonies in North America: three in Newfoundland and three in the Quebec Gulf of St.Lawrence. The northern gannet frequents the open waters of the Gulf of St.Lawrence from late March until November, exceptionally into December. The largest colony is on Bonaventure Island, Quebec, which counted more than 53 000 pairs in 2004. In the same year, 23 500 pairs were counted on Rocher-aux-Oiseaux and another 221 at the northeast point of Anticosti Island[19].

- FEEDING: Northern gannets are spectacular divers, plunging into the ocean at high speed, with their bodies completely straightened out like an arrow before striking the water. If a fish is taken after diving, gannets swallow the fish underwater before surfacing. Although they are strong and agile fliers, they are clumsy in takeoffs and landings. They mainly eat small fish (2.5-30.5 cm in length) which gather in groups near the surface. Virtually any small fish (roughly 80-90% of the diet) or other small pelagic species (largely squid) will

[19] http://www.qc.ec.gc.ca/faune/coloniesdeoiseauxdemer/espece_e.asp?id_espece=1170

be taken opportunistically. Various cod, smelt, and herring species are most frequently taken[20].

- BREEDING: Northern gannets breed only in the North Atlantic. At the end of the breeding season, the birds head down the U.S. east coast to Florida and the Gulf of Mexico to winter. They breed in crowded colonies on rocky islands and clifftops, exposed to the wind for easy takeoff. The female lays a single egg, which takes an average of 44 days to incubate. The chick is fed by both parents for 82 to 99 days. Juveniles take five years to mature, gradually losing their brown plumage. During that time, they roam far over the ocean before returning to their native colony to breed.

3.1.5 Loop Current

During the first weeks following the explosion at the Deepwater Horizon oil well in the Gulf of Mexico, oil drifting from the site of the incident usually headed west and northwest to the Mississippi Delta. But in the third week of May, currents drew some of the oil southeast. According to NOAA, this behaviour of the surface oil area was due to the Loop Current, a current in the Gulf of Mexico. The researches of NOAA believe that the Loop Current assisted in the spreading of the surface oil spill area in the Gulf[21].

A parent to the Florida Current, the **Loop Current** is a warm ocean current in the Gulf of Mexico that flows northward between Cuba and the Yucatan peninsula, moves north into the Gulf of Mexico, loops east and south before exiting to the east through the Florida Straits and joining the Gulf Stream (see Figure 13).

[20] `http://bna.birds.cornell.edu/bna/species/693/articles/foodhabits`
[21] `http://earthobservatory.nasa.gov/IOTD/view.php?id=44036`
[22] `http://en.wikipedia.org/wiki/Loop_Current`

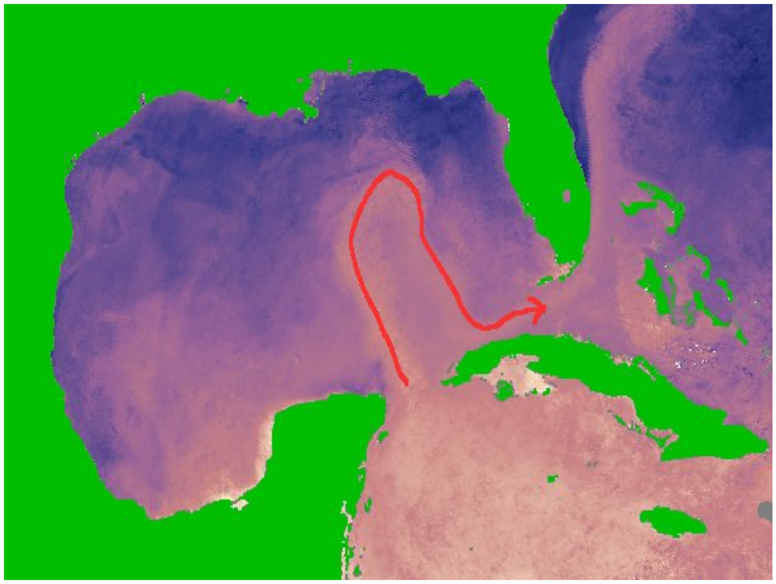
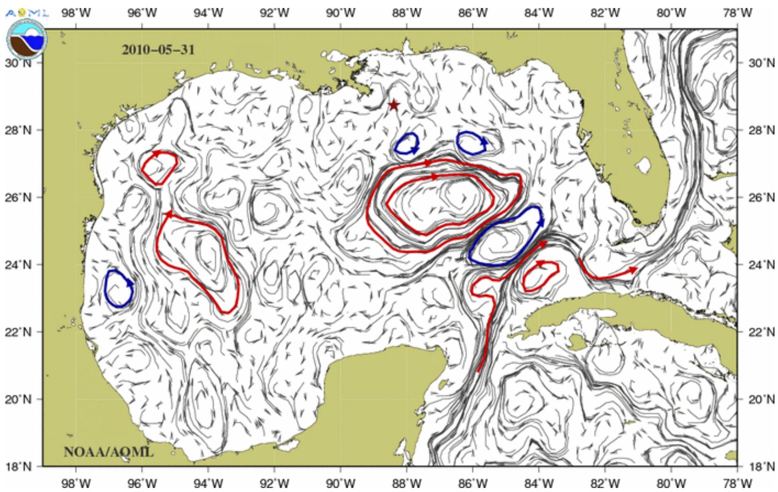


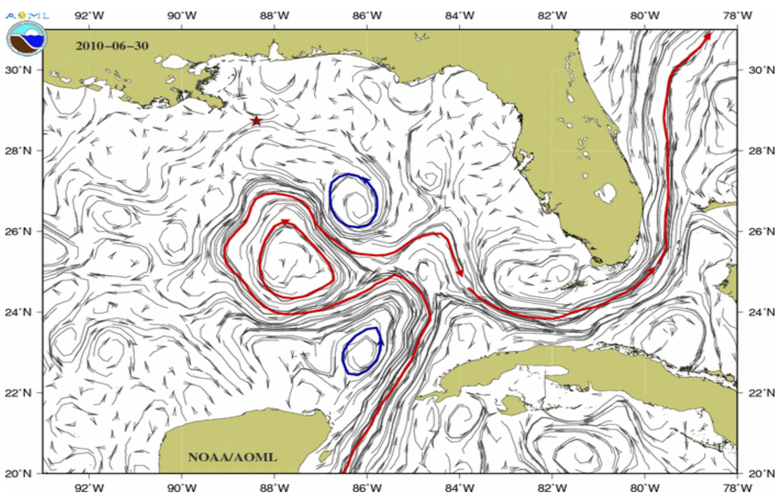
Fig. 13: Loop Current[22]

Moreover, Fugure 14 displays the Loop Current's direction on May 31, June 30, and July 31 of 2010 in the Gulf of Mexico. These days were chosen to show the Loop Current's possible effect later in this section on the spreading out the surface oil spill in the Gulf in May, June, and July of 2010.

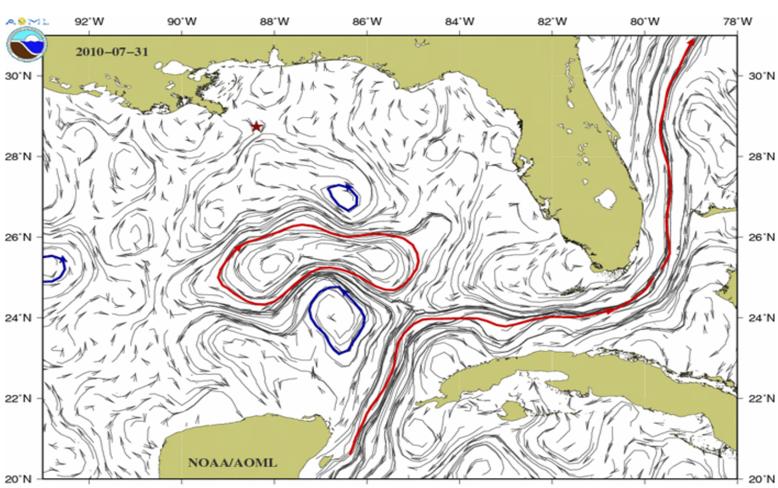
[23]http://www.aoml.noaa.gov/phod/dhos/geos.php



(a) Loop Current for May 31, 2010[23]



(b) Loop Current for June 30, 2010[23]



(c) Loop Current for July 31, 2010[23]

Fig. 14: The surface currents in the Gulf of Mexico. The red star indicates the location of the Deepwater Horizon. The solid contours indicate the location of the Loop Current and anticyclonic rings and eddies (red) and cyclonic eddies (blue).

Table 9: Variables of the bird data

Variables	Details of Variable
Species	Bird species: 92 identified, 25 unidentified, unknown and other species
Latitude Longitude	Spatial locations of birds
Oiling	Three types: not visibly oiled, visibly oiled and unknown
Condition	Dead or alive status of bird species
BirdCount	single integer “1”
Date	Daily observations from May 5, 2010, to October 17, 2010
Oil Condition	There are six oil conditions ”1-6”
Week number	Week numbers from 19 to 42

3.2 Observed Data

The USFWS provided a data set of 7,229 bird records. The bird data is available on `http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/birds.csv`. R code for reading bird data can be found in Appendix B.3.1. The Bird data has the following variables (see Table 9):

The *Species* variable contains 92 identified, 25 unidentified, unknown, and other species. The unidentified species describe bird species which belong to the specific family of birds but their type was unidentified. For example, American white pelican and brown pelican are members of the family Pelecanidae. But the researchers observed the other species from the Pelecanidae family whose types were unidentified and they referred them as “unidentified pelican”.

The spatial locations of bird data are represented by the *Latitude* and *Longitude* variables. They contain all spatial locations from 24.62759^o to 30.62032^o in latitude and from -95.6384^o to -82.03223^o in longitude. The *BirdCount* variable indicates the observed counts of birds for the corresponding bird species. In fact, all observations have a single count.

The *Week number* variable in Table 9 contains all weeks from May 5, 2010, until

Table 10: Biological orders of bird species

N	Biological Orders	Number of Species	Number of Observations	Bird Species
1	Accipitriformes	2	2	Red-tailed Hawk, Unidentified Hawk
2	Anseriformes	8	52	Canada Goose, Lesser Scaup, Mallard, Mottled Duck, Red-Breasted Merganser, Rudy Duck, Surf Scoter, Unidentified Duck
3	Caprimulgiformes	1	1	Common Nighthawk
4	Charadriiformes	34	4421	American Oystercatcher, Black Oystercatcher, Black Skimmer, Black Tern, Black-necked Stilt, Blue-winged Teal, Caspian Tern, Common Tern, Forster's Tern, Gull-billed Tern, Herring Gull, Killdeer, Laughing Gull, Least Tern, Lesser Black-backed Gull, Long-Billed Dowitcher, Piping Plover, Ring-billed Gull, Royal Tern, Ruddy Turnstone, Sanderling, Sandwich Tern, Semipalmated Sandpiper, Short-billed Dowitcher, Sooty Tern, Spotted Sandpiper, Unidentified Dowitcher, Unidentified Gull, Unidentified Sandpiper, Unidentified Shorebird, Unidentified Skimmer, Unidentified Tern, Willet, Wilson's Plover
5	Ciconiiformes	16	256	Black Crowned Night Heron, Cattle Egret, Glossy Ibis, Great Blue Heron, Great Egret, Great Horned Owl, Green Heron, Least Bittern, Little Blue Heron, Reddish Egret, Roseate Spoonbill, Snowy Egret, Tricolored Heron, Unidentified Heron, White Ibis, Yellow-crowned Night-Heron
6	Columbiformes	5	39	Eurasian Collared-Dove, Mourning Dove, Rock Pigeon, Unidentified Pigeon, White-winged Dove
7	Coraciiformes	1	2	Belted King Fisher
8	Cuculiformes	1	2	Yellow-billed Cuckoo
9	Falconiformes	1	10	Osprey
10	Gaviiformes	3	104	Common Loon, Common Moorhen, Unidentified Loon
11	Gruiformes	6	115	American Coot, Clapper Rail, Purple Gallinule, Sora, Unidentified Rail, Virginia Rail
12	Passeriformes	18	32	American Redstart, Barn Swallow, Boat-tailed Grackle, Common Yellowthroat, Eastern Kingbird, Eastern Meadowlark, House Sparrow, Northern Cardinal, Northern Mockingbird, Purple Martin, Red-winged Blackbird, Seaside Sparrow, Unidentified Blackbird, Unidentified Flycatcher, Unidentified Grackle, Unidentified Mockingbird, Unidentified Sparrow, Unidentified Swallow
13	Pelecaniformes	10	1436	American White Pelican, Brown Pelican, Double-crested Cormorant, Magnificent Frigatebird, Masked Booby, Neotropic Cormorant, Northern Gannet, Unidentified Cormorant, Unidentified Egret, Unidentified Pelican
14	Podicipediformes	3	47	Horned Grebe, Pied-bill Grebe, Unidentified Grebe
15	Procellariiformes	5	32	Audubon's Shearwater, Greater Shearwater, Manx Shearwater, Unidentified Shearwater, Wilson's Storm-petrel
16	Stigiformes	2	2	Barn Owl, Unidentified Owl
17			526	Unknown
18			149	Other, including "Unidentified Raptor" bird species

October 17, 2010. More precisely, alive birds were observed from week 19 to week 40, while the dead birds were observed from week 19 to week 42. A week covers seven consecutive days from Monday to Sunday. For example, week 24 covers dates from Monday, June 07, 2010, until Sunday, June 13, 2010.

From the given variables (see Table 9), the *Oil Condition* variable provides six oil conditions ("1 - 6") of the dead and alive bird species. Table 9 also shows that the bird data contains a large number of bird species. To simplify our analysis, we gather bird species into groups by their biological orders. Table 10 shows 16 biological orders and related bird species, as well as unknown and other bird species. The bird species are divided by their biological orders according to the study completed by Yazdanparast et al. (2011).

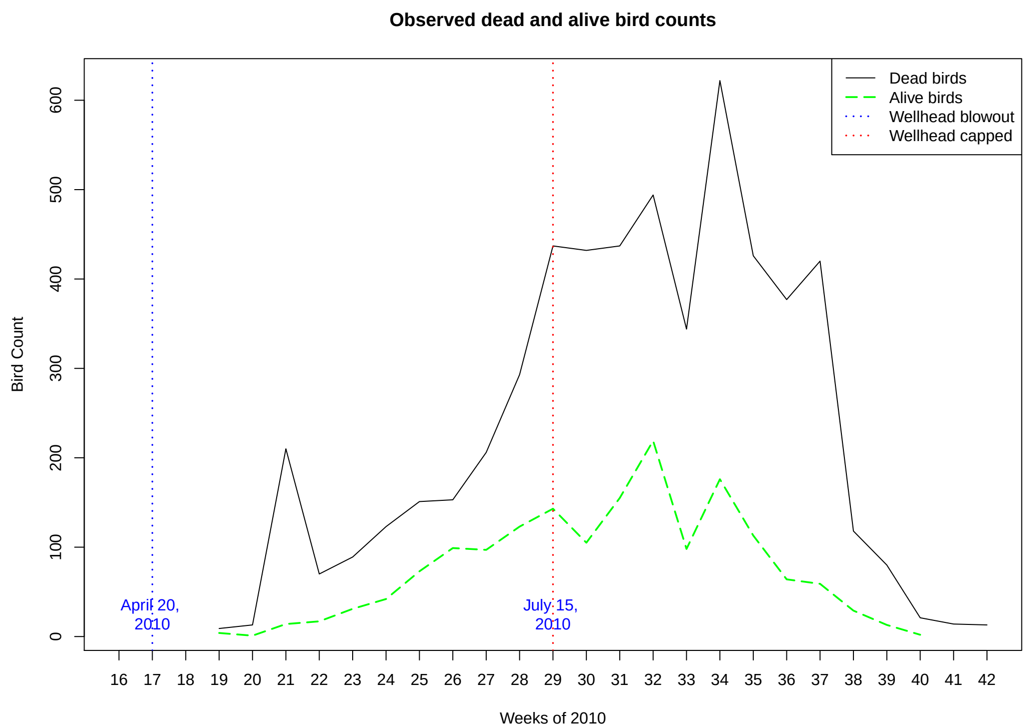


Fig. 15: The time series of dead and alive bird counts in 2010

3.3 Results

In this section, we examine all variables of the bird data in the graphical framework, except the *BirdCount* and *Oil Condition* variables (see Table 9). The *BirdCount* represents a single count ("1") for each observation on the row of the bird data. This variable does not provide any helpful information in our analysis. The *Oil Condition* variable delivers a mixed information regarding oil conditions of the observed dead or alive bird species. The oil conditions of the dead birds were "3", "4", and "5", while the alive birds had oil conditions "1", "2", and "6". We don't know whether small oil conditions represent a heavy or light oil covering of birds. The bird data does not provide any details and our search for any explanation about this variable was unsuccessful. Thus, we dropped these variables from further analysis.

We first want to visualize the time series of the living status of birds during the observed data period. Figure 15 shows the time period from week 16 to week 42 for 2010. We can see that the Deepwater Horizon oil wellhead was blown out on April 20, 2010, in week 17 and it was capped on July 15, 2010, in week 29. The observed dead birds are represented by the solid black lines, while the alive birds are represented by green dashed lines. R code for Figure 15 can be found in Appendix B.3.2.

Figure 16 shows the time series of dead and alive birds for all 16 biological orders, as well as unknown and other bird species. The dead and alive birds are represented in a similar way as in Figure 15. R code for Figure 16 can be found in Appendix B.3.3.

We can also visualize the bird data in a spatial and temporal framework. Figure 17 displays the observed dead and alive birds by oiling condition from May to October in 2010. The dead and alive birds are represented by blue and red symbols, respectively. We use circle ("o"), square ("□") and triangle ("△") symbols to denote visibly oiled, not visibly oiled, and unknown oiling conditions, respectively.

The surface oil spill areas were obtained from NOAA. The surface oil spill areas are shown mainly in Figures 17(a), 17(b), and 17(c). Since the Deepwater Horizon oil wellhead was capped on July 15, 2010, we can see a very small oil spill area in August 2010 (see Figure 17(d)) and no oil spill areas in September (see Figure 17(e)) and October (see Figure 17(f)) of 2010. R code for Figure 17 can be found in Appendix B.3.7.

Figures 18, 19, 20, and 21 show the observed dead and alive birds by the oiling conditions for weeks 19 to 42 of 2010. The living and oiling status of dead and alive birds are denoted similarly as in Figure 17. Figures 18, 19, and 20 also display the surface oil spill areas for the corresponding weeks. The surface oil spill areas are usually displayed on the last days of weeks in the plots. Figure 18(a) shows the surface oil spill area on May 9, 2010 which was the last day of week 19. However,

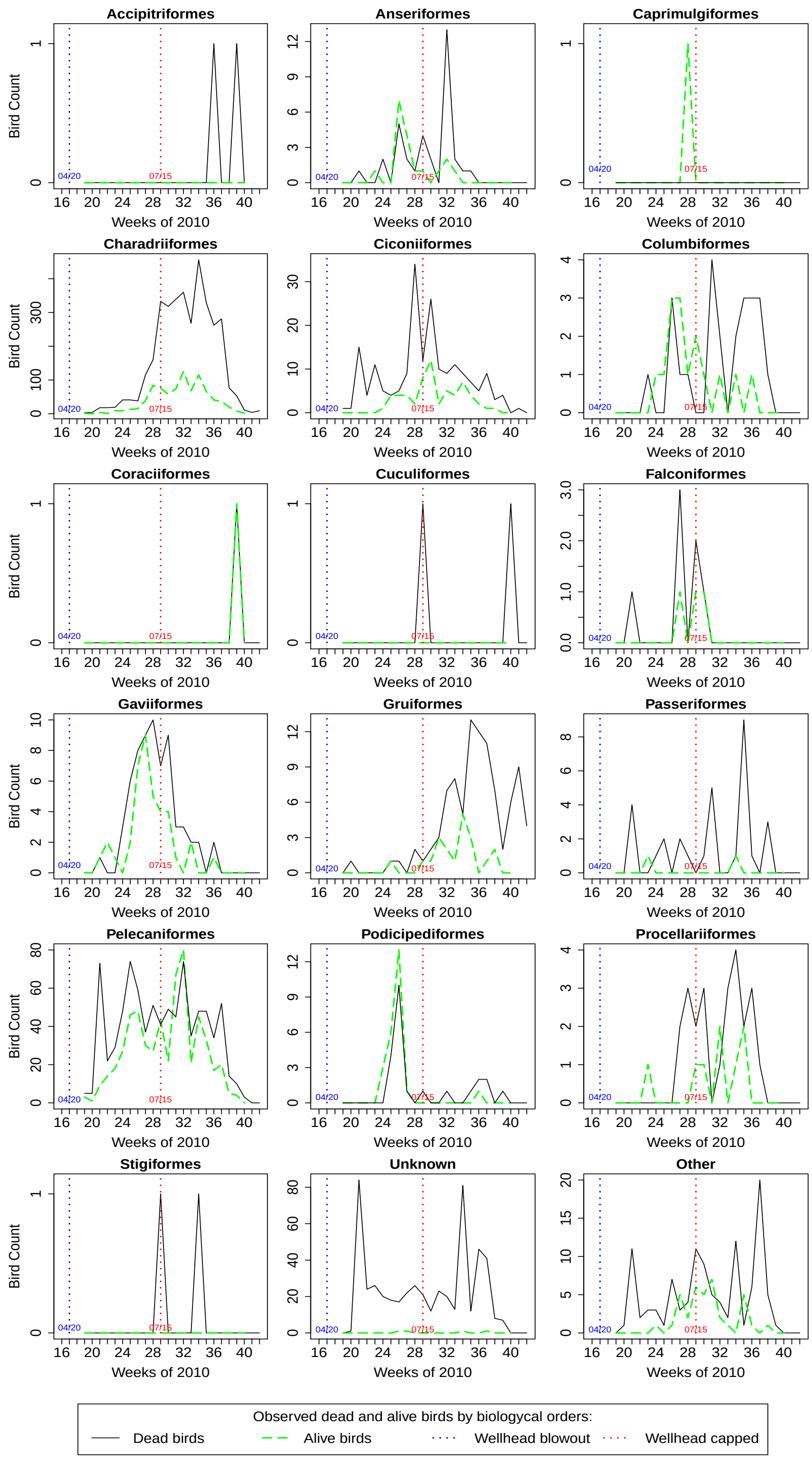
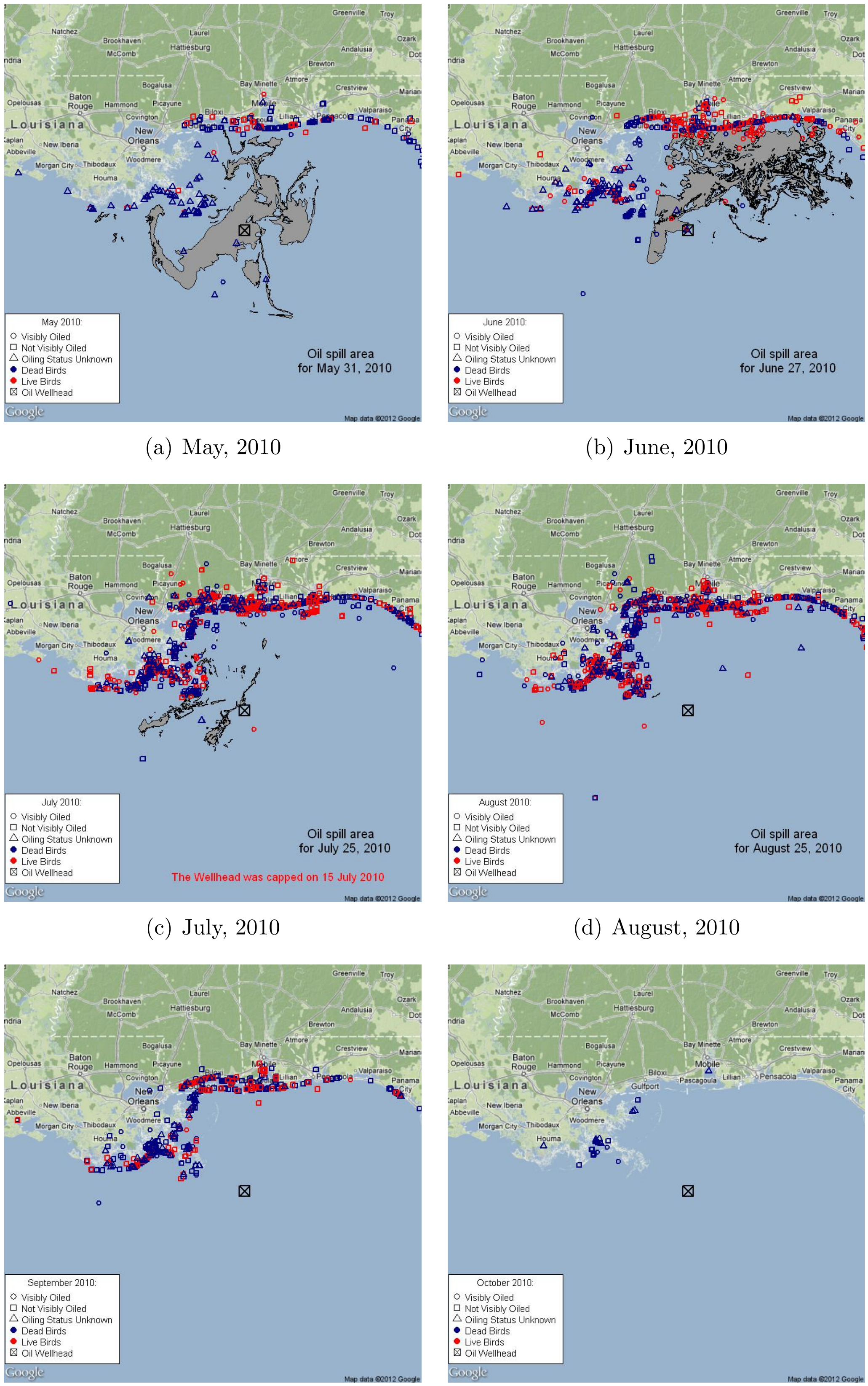


Fig. 16: The time series of dead and alive bird counts by biological orders



(a) May, 2010

(b) June, 2010

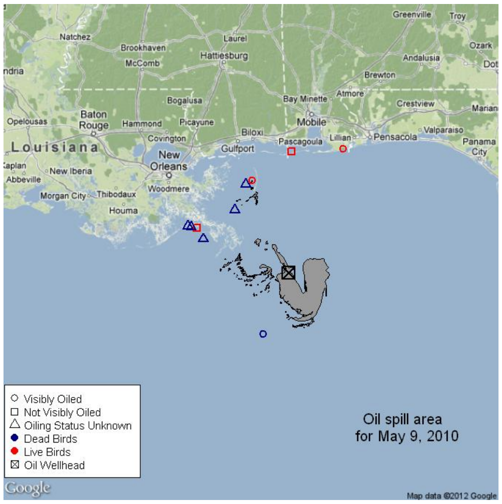
(c) July, 2010

(d) August, 2010

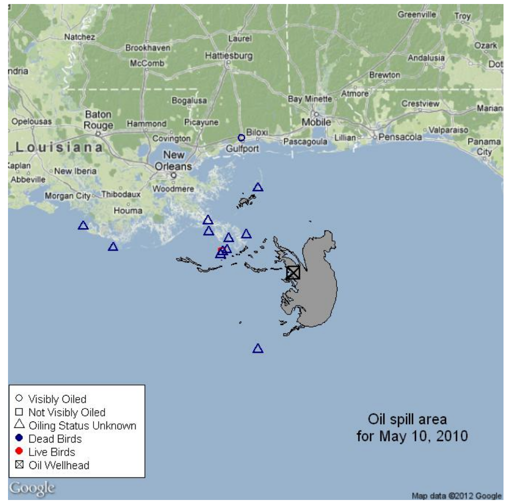
(e) September, 2010

(f) October, 2010

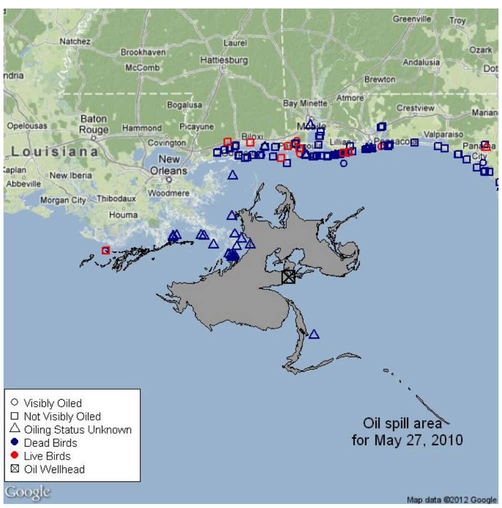
Fig. 17: Dead and alive birds within months of 2010



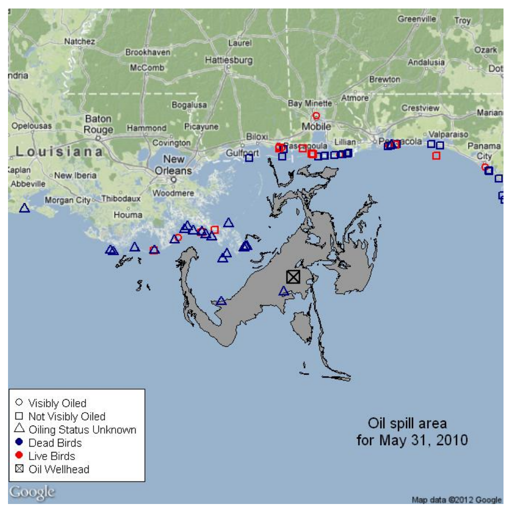
(a) Week 19 (May 3 - 9, 2010)



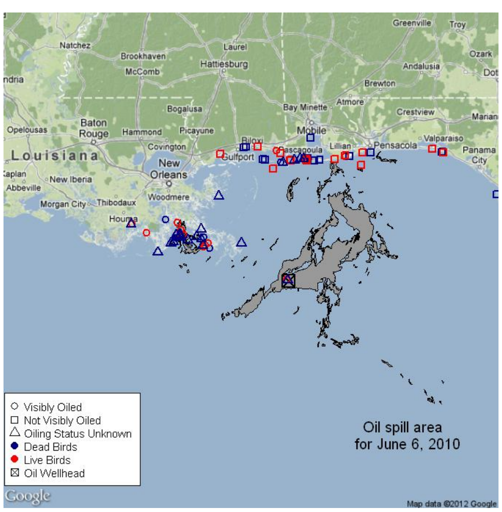
(b) Week 20 (May 10 - 16, 2010)



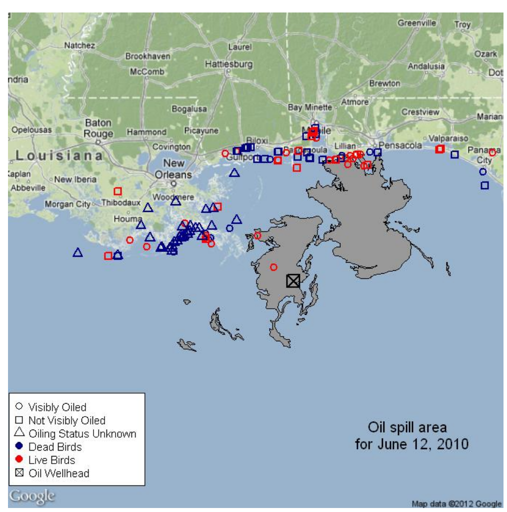
(c) Week 21 (May 17 - 23, 2010)



(d) Week 22 (May 24 - 30, 2010)

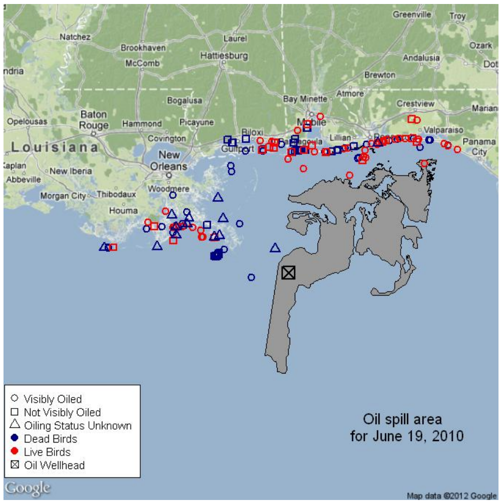


(e) Week 23 (May 31 - June 6, 2010)

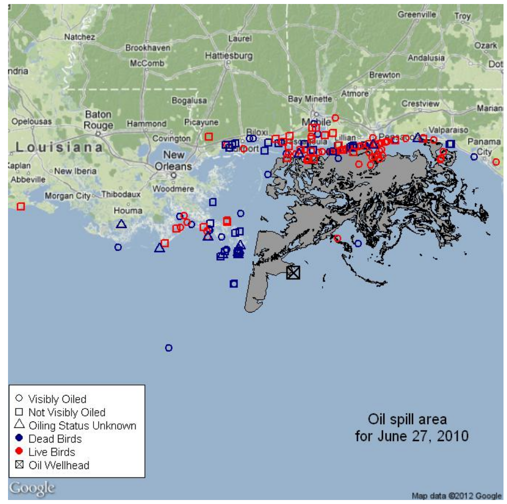


(f) Week 24 (June 7 - 13, 2010)

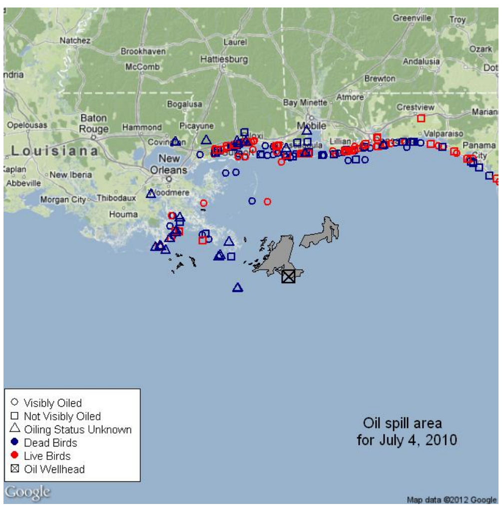
Fig. 18: Dead and alive birds for weeks 19 - 24 of 2010



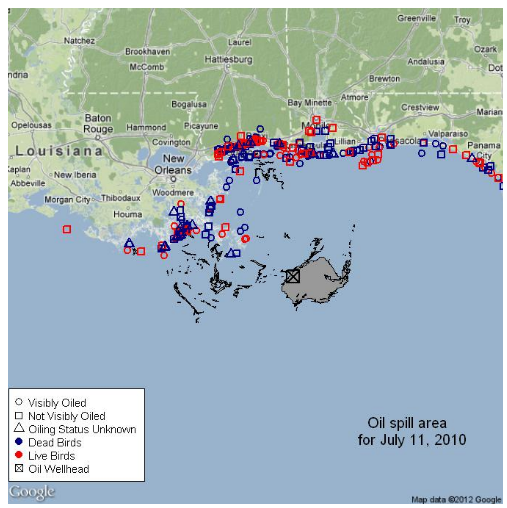
(a) Week 25 (June 14 - 20, 2010)



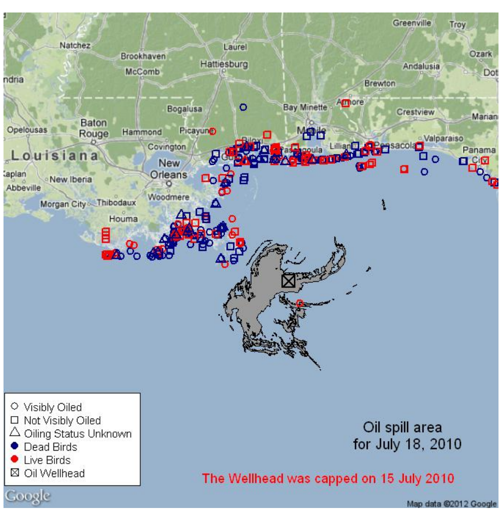
(b) Week 26 (June 21 - 27, 2010)



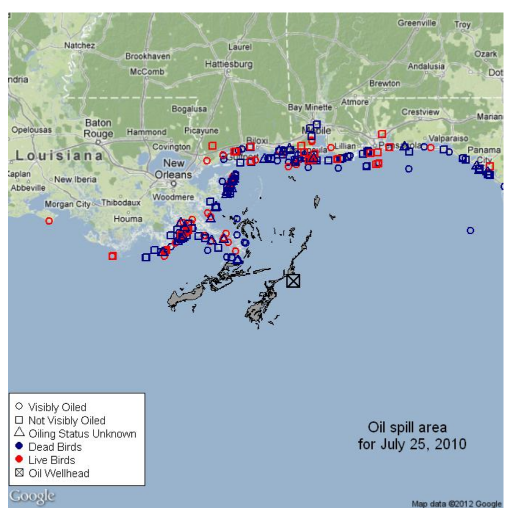
(c) Week 27 (June 28 - July 4, 2010)



(d) Week 28 (July 5 - 11, 2010)

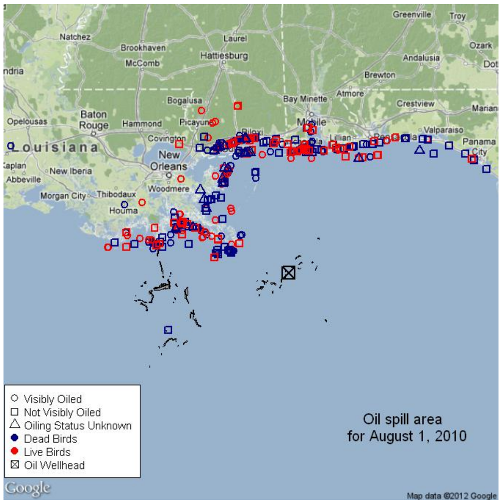


(e) Week 29 (July 12 - 18, 2010)

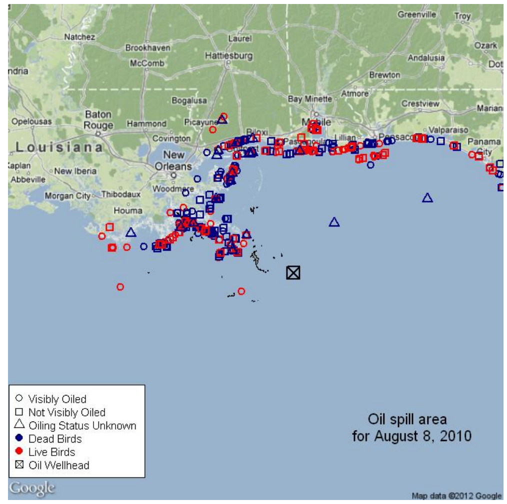


(f) Week 30 (July 19 - 25, 2010)

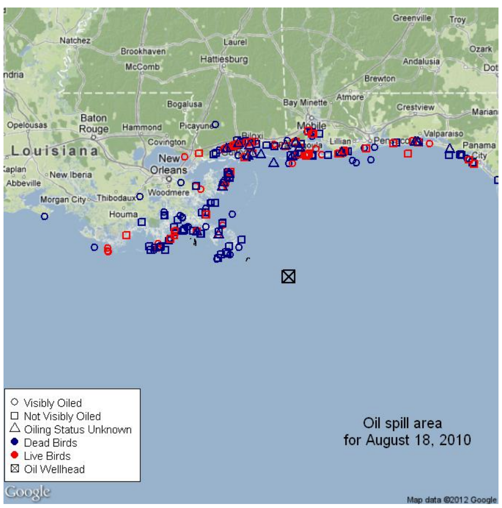
Fig. 19: Dead and alive birds for weeks 25 - 30 of 2010



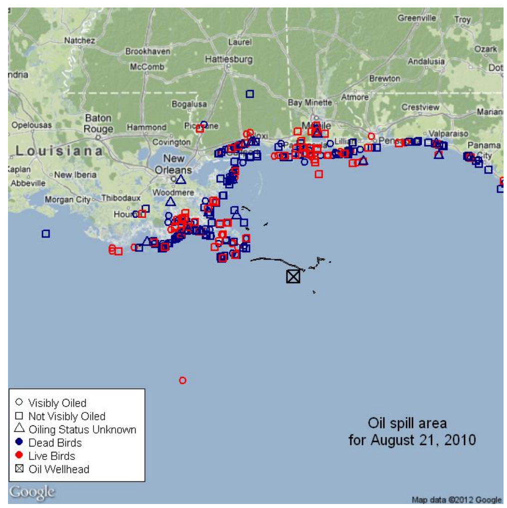
(a) Week 31 (July 26 - August 1, 2010)



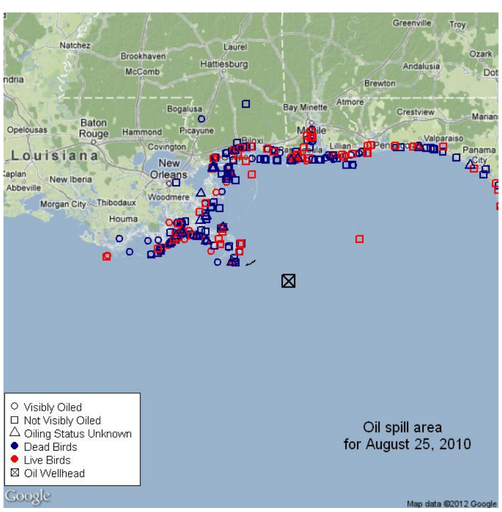
(b) Week 32 (August 2 - 8, 2010)



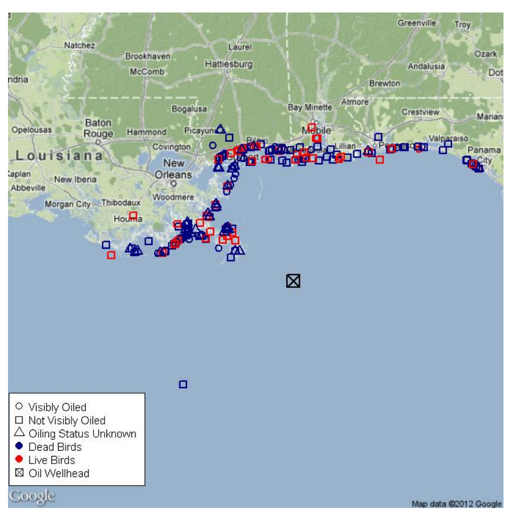
(c) Week 33 (August 9 - 15, 2010)



(d) Week 34 (August 16 - 22, 2010)

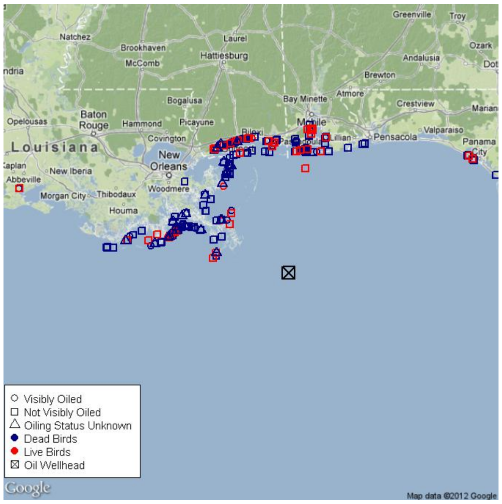


(e) Week 35 (August 23 - 29, 2010)

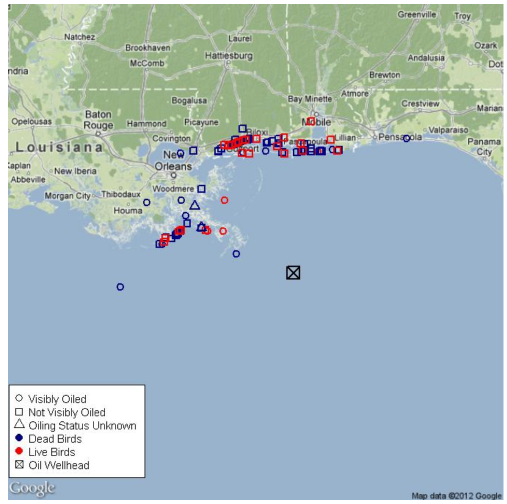


(f) Week 36 (August 30 - September 5, 2010)

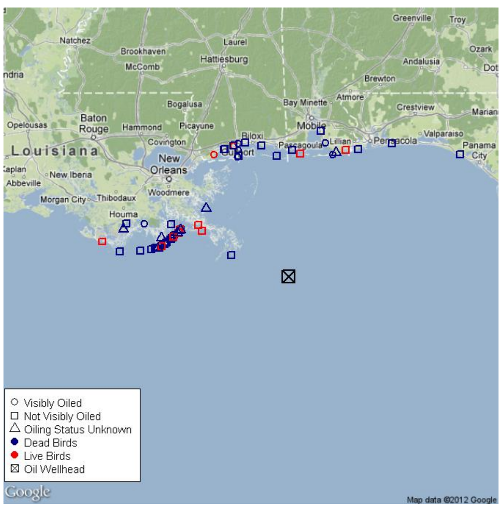
Fig. 20: Dead and alive birds for weeks 31 - 36 of 2010



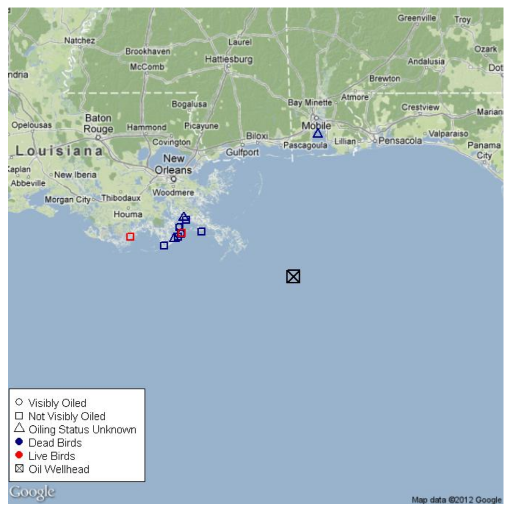
(a) Week 37 (September 6 - 12, 2010)



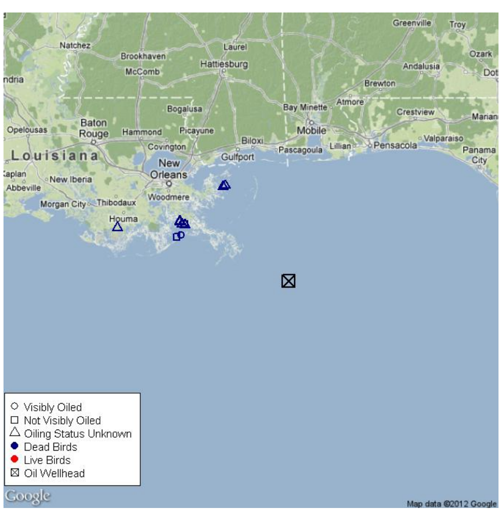
(b) Week 38 (September 13 - 19, 2010)



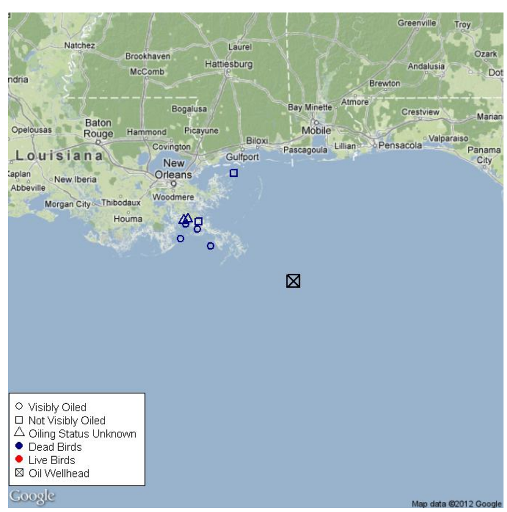
(c) Week 39 (September 20 - 26, 2010)



(d) Week 40 (September 27-October 3, 2010)



(e) Week 41 (October 4 - 10, 2010)



(f) Week 42 (October 11 - 17, 2010)

Fig. 21: Dead and alive birds for weeks 37 - 42 of 2010

each daily remote sensing data of the Deepwater Horizon oil spill areas is not available or not operational. Thus, we used the remote sensing data from the closest dates in case the data on the specific day is not available or operational. For example, Figure 18(d) displays the oil spill area from May 31, 2010, while the last day of week 22 was May 30, 2010. Though the oil spill well was capped on July 15, 2010, in week 29 (see Figure 19(e)), we can see a small oil spill areas in weeks 30 to 35 (see Figures 19 and 20). Figure 20(e) shows the last available and operational oil spill area on August 25, 2010. R code for Figures 18, 19, 20, and 21 can be found in Appendix B.3.8.

Inspired by the barplots on frequencies of bird counts in Yazdanparast et al. (2011), Figures 22, 23 and 24 were drawn to show frequencies of dead and alive bird species by their biological orders, oiling, and living conditions. Though our main interest is to find any relationships between the observed dead birds and the oil spill and its spreading area, we may be interested in seeing the relationship between the oil spill and the alive bird counts with visibly oiled status.

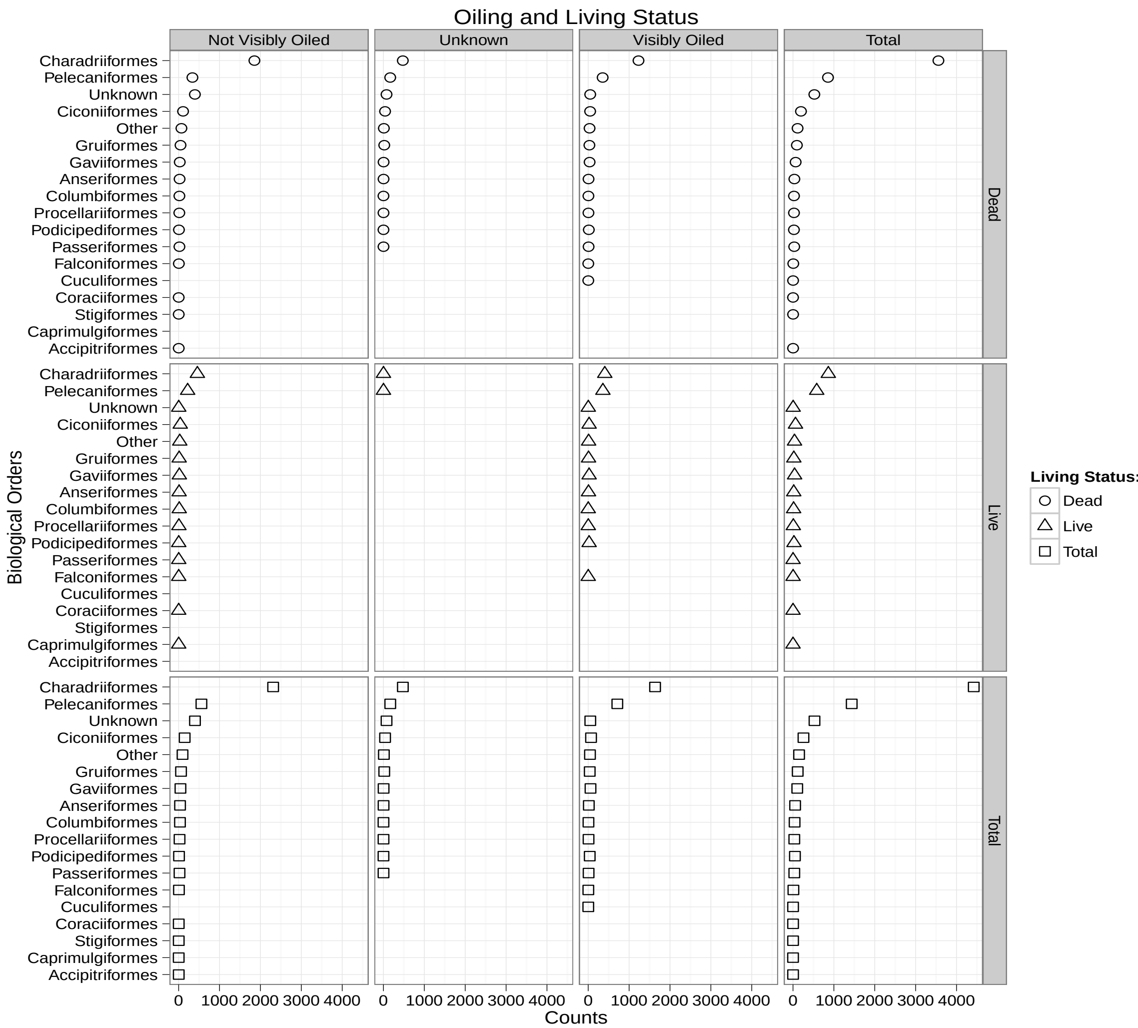


Fig. 22: Frequencies by biological order, oiling, and living status

Figure 22 displays frequencies of bird counts by their biological orders, oiling, and living statuses. From the dotplot, we can see that two biological orders, Charadriiformes and Pelecaniformes have the largest observed bird data. Thus, we restricted further analyses by far of bird species to these two biological orders. R code for Figure 22 can be found in Appendix B.3.4.

Figure 23 shows frequency counts of the Charadriiformes biological order by bird species, oiling, and living status. Laughing gulls are the most frequently observed bird species for this biological order. R code for Figure 23 can be found in Appendix

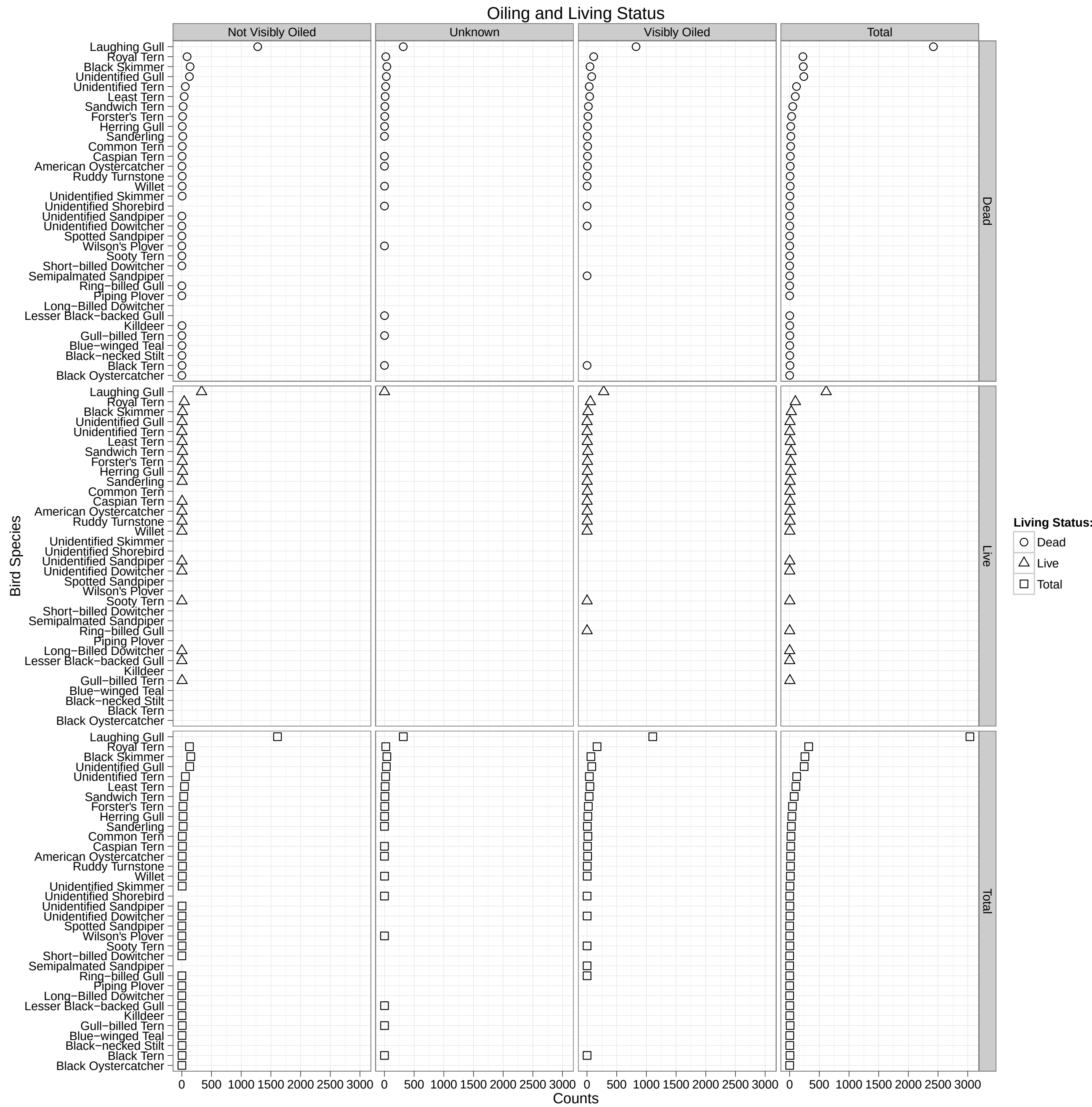


Fig. 23: Frequencies of Charadriiformes biological order by species, oiling, and living status

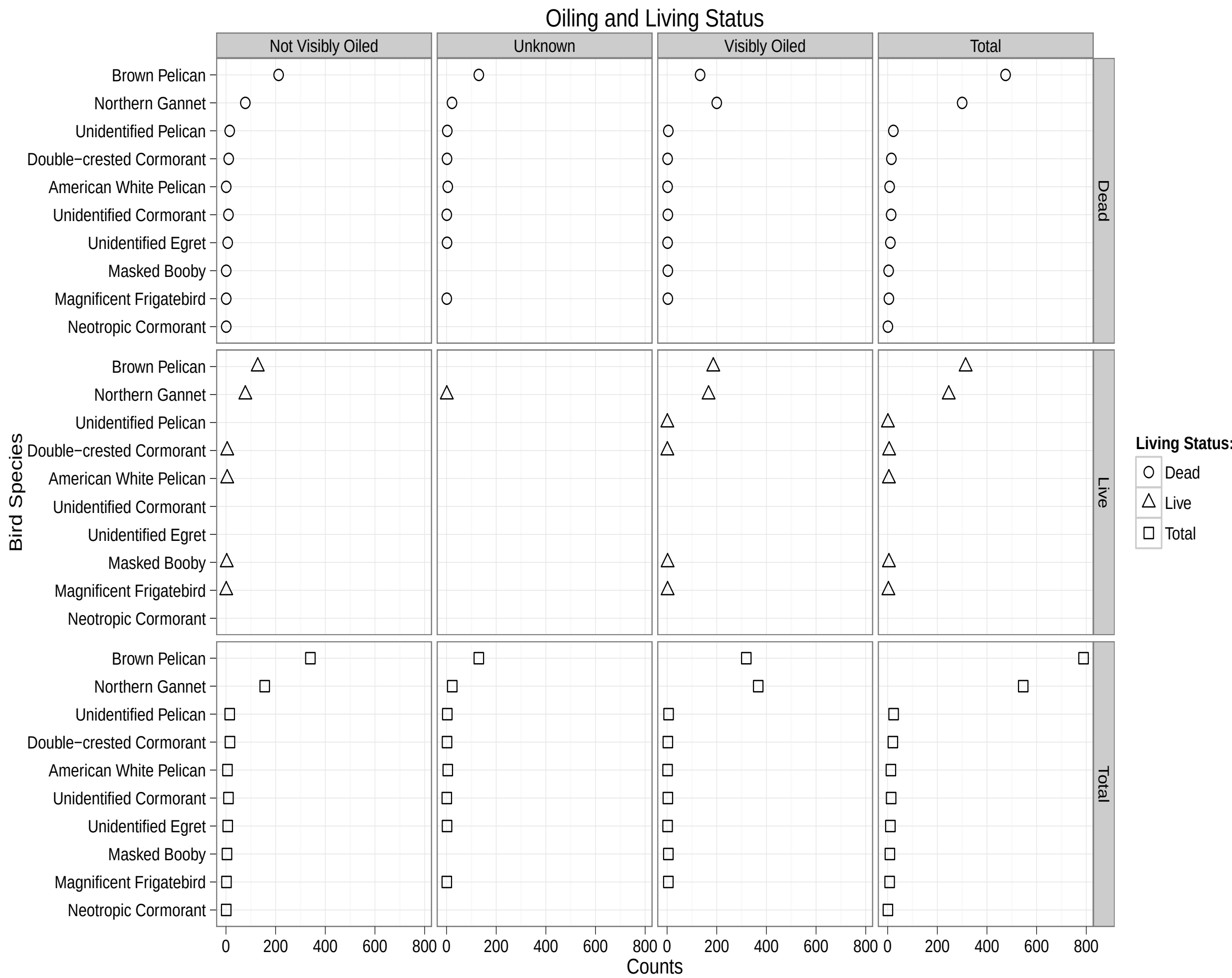


Fig. 24: Frequencies of Pelecaniformes biological order by species, oiling, and living status

B.3.5.

Similarly, Figure 24 presents frequency counts of the Pelecaniformes biological order by bird species, oiling, and living status. Brown pelican and northern gannet bird species have the largest observed data. R code for Figure 24 can be found in Appendix B.3.6.

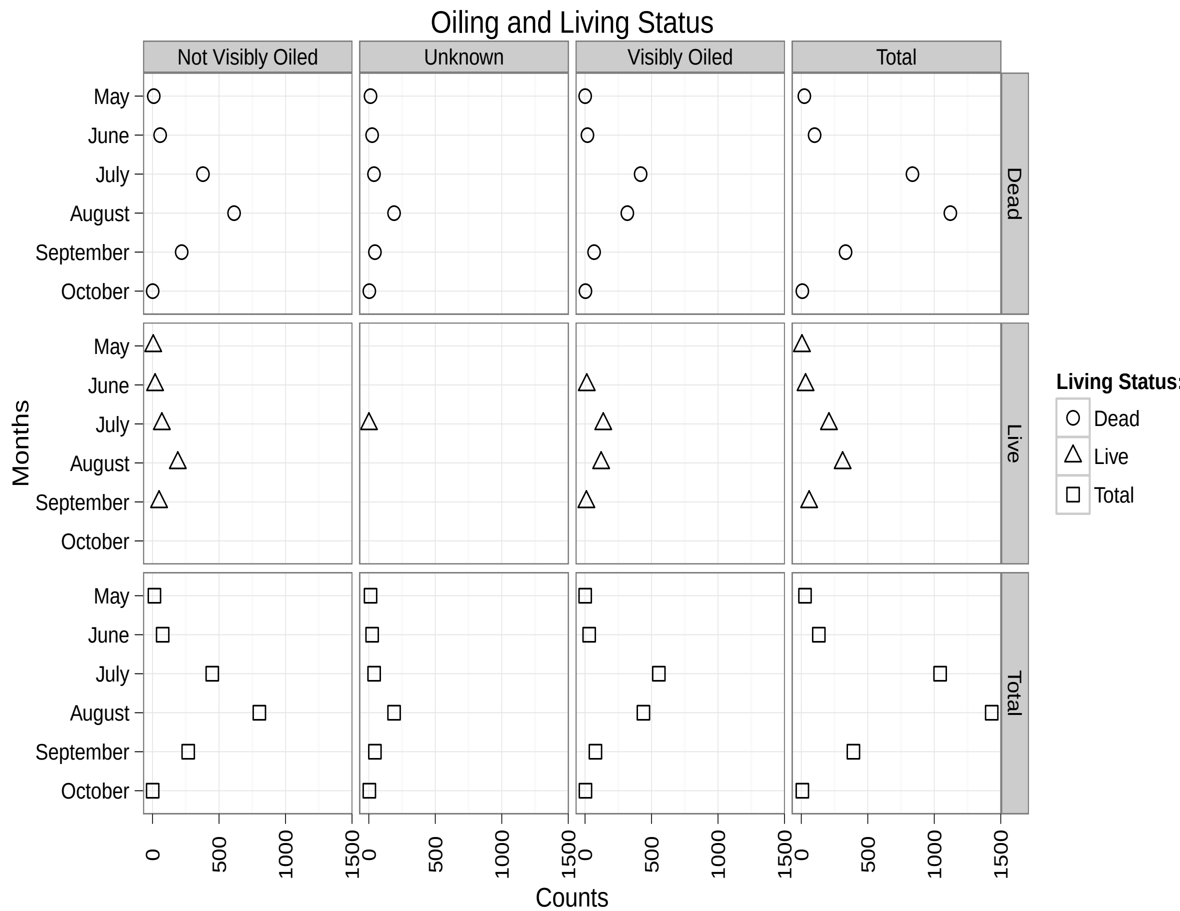
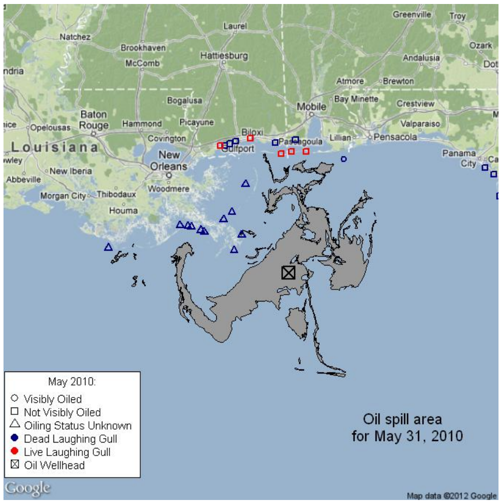
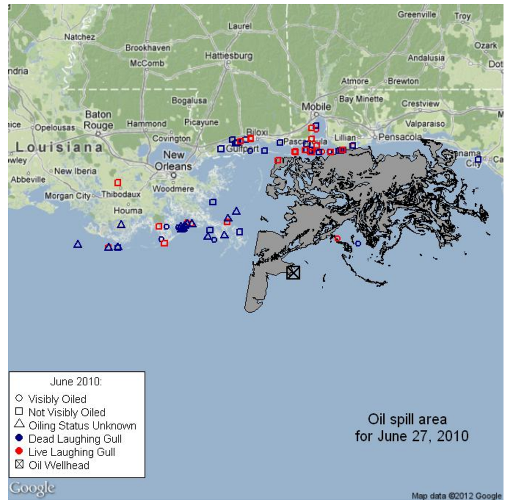


Fig. 25: Frequencies of laughing gull by months, oiling, and living status

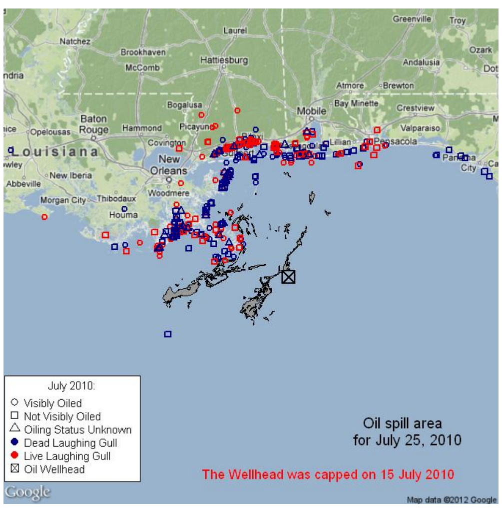
Previously, we noticed in Figure 23 that the laughing gull was the major observed bird species in the Charadriiformes biological order. Figure 25 shows the observed number of dead and alive laughing gulls by oiling and living conditions and Figure 26 shows their spatial and temporal locations. R code for Figures 25 and 26 can be found in Appendices B.3.9 and B.3.10, respectively.



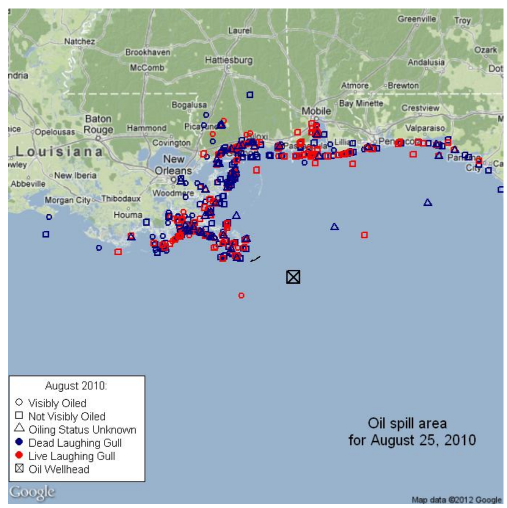
(a) May, 2010



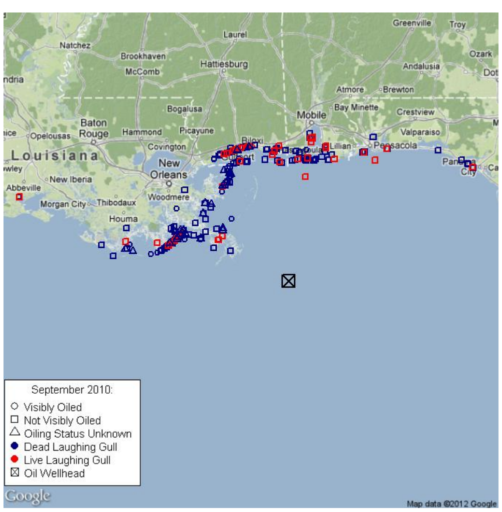
(b) June, 2010



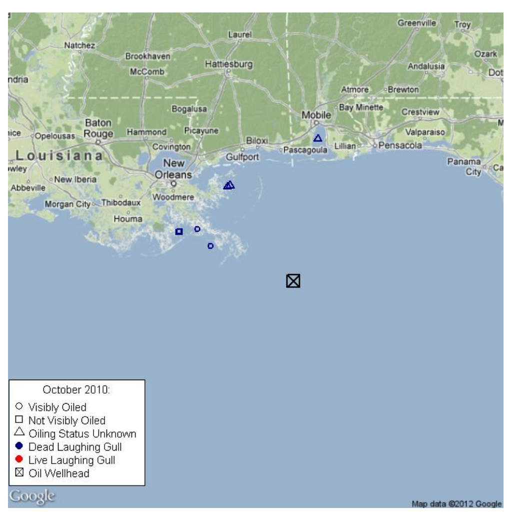
(c) July, 2010



(d) August, 2010



(e) September, 2010



(f) October, 2010

Fig. 26: Laughing gull within months of 2010

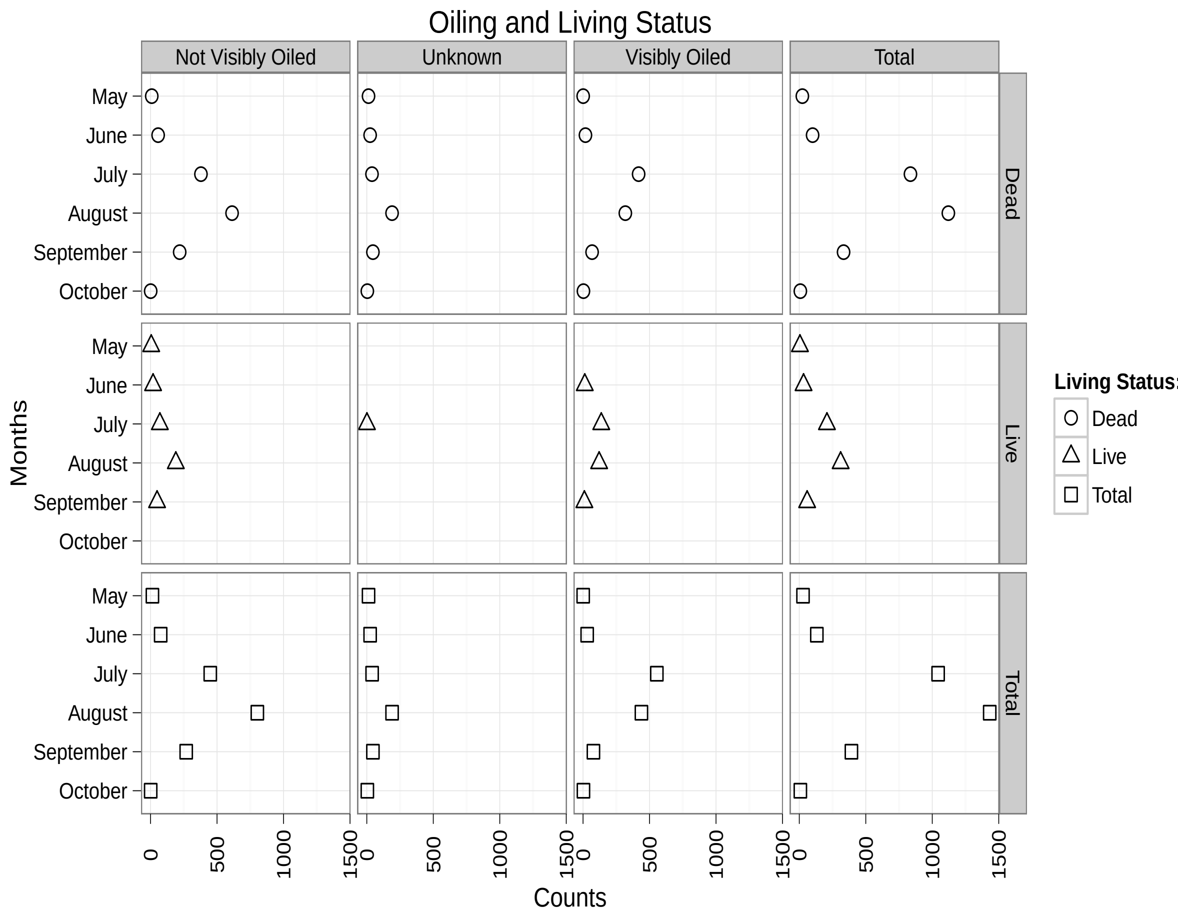
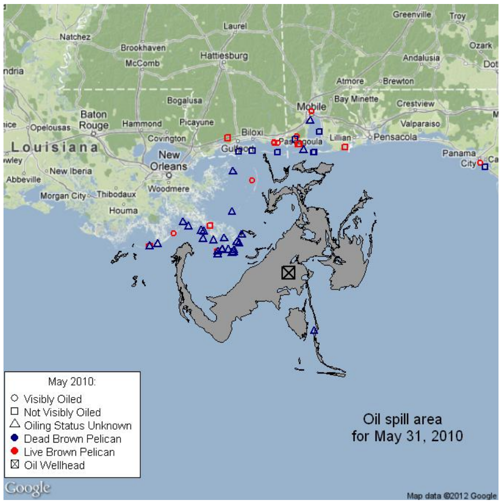
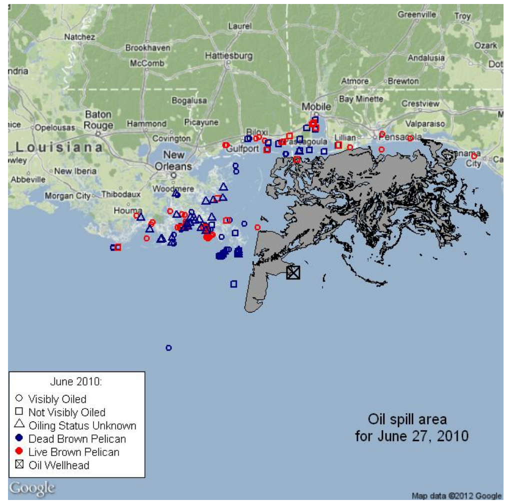


Fig. 27: Frequencies of brown pelican by months, oiling, and living status

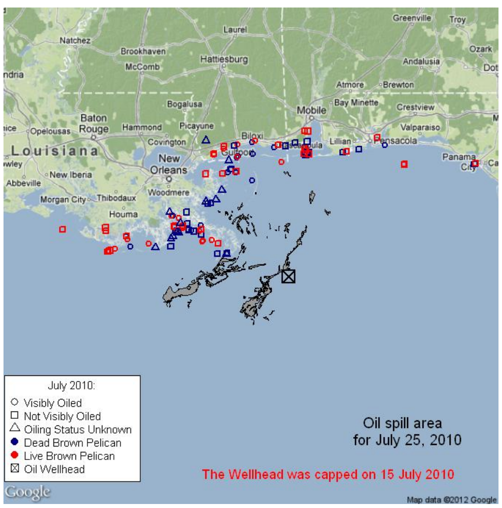
From the Pelecaniformes biological order, brown pelican and northern gannet were the most frequently observed bird species (see Figure 24). Figures 27 and 28 show the dead and alive brown pelican counts by oiling and live conditions, as well as the spatial locations of them in temporal framework from May to September of 2010. R code for these figures can be found in Appendices B.3.11 and B.3.12, respectively.



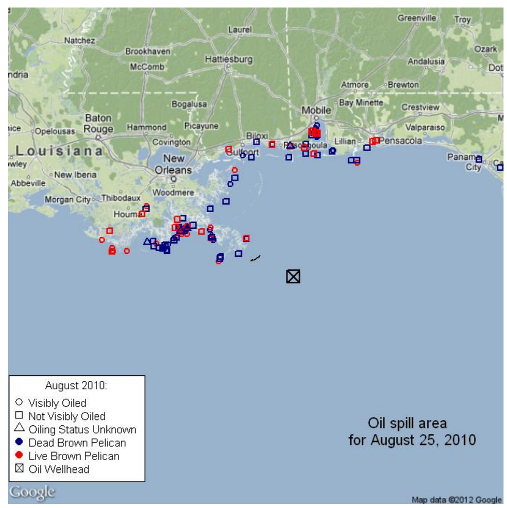
(a) May, 2010



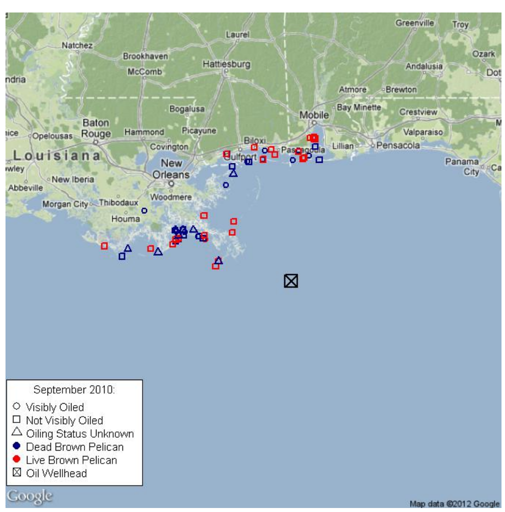
(b) June, 2010



(c) July, 2010



(d) August, 2010



(e) September, 2010

Fig. 28: Brown pelican within months of 2010

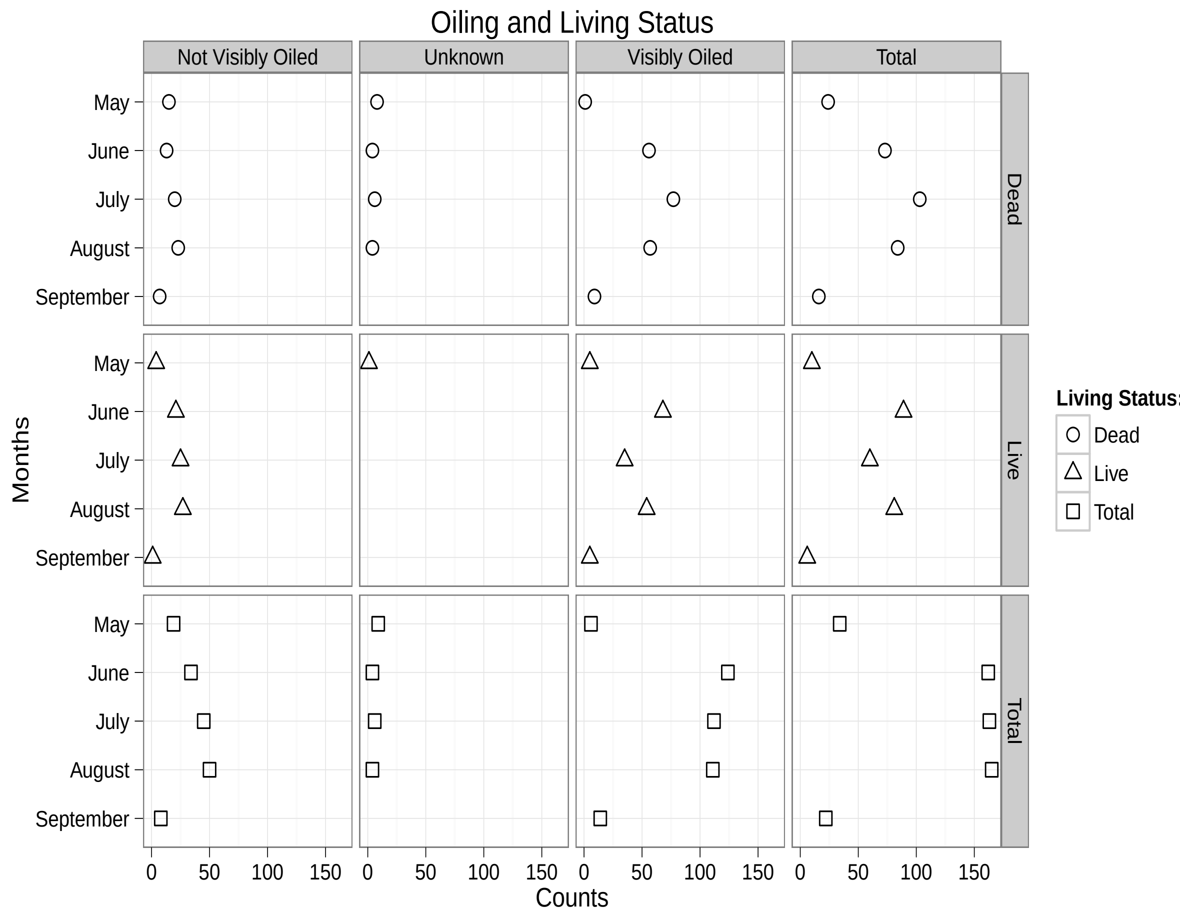
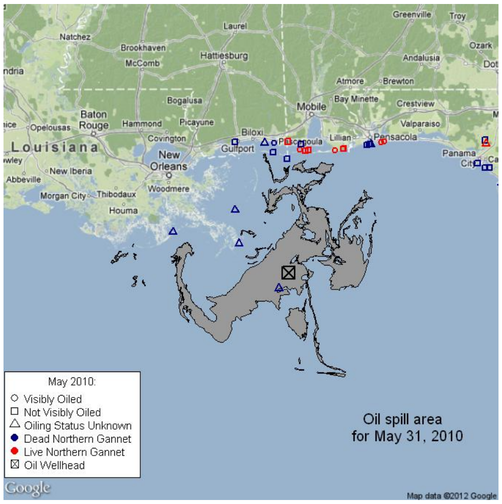
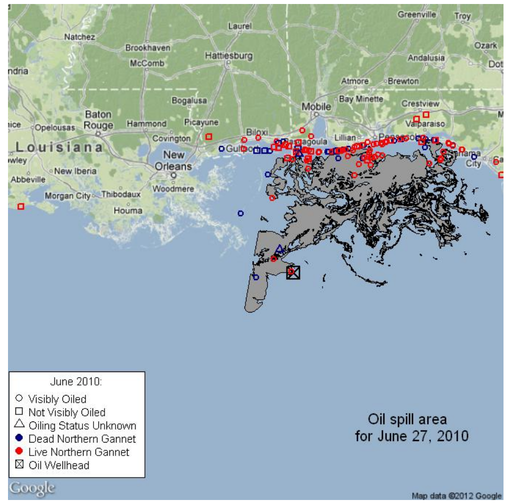


Fig. 29: Frequencies of northern gannet by months, oiling, and living status

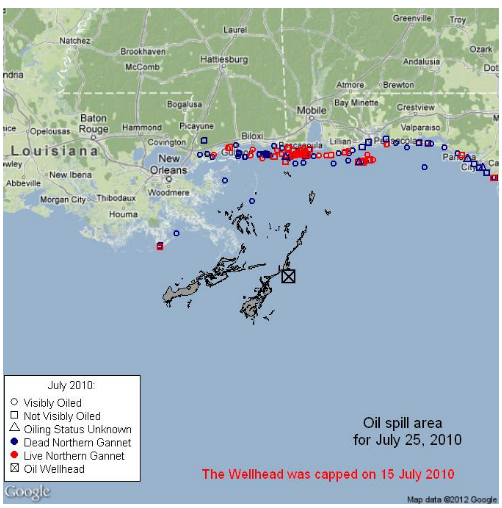
Similarly, the observed dead and alive northern gannets by oiling and living conditions are shown in Figure 29 with their spatial and temporal visualization in Figure 30. Compared to the spatial and temporal locations of dead and alive laughing gulls (see Figure 26), brown pelicans and northern gannets were not observed in October 2010. R code for these plots can be found in Appendices B.3.13 and B.3.14, respectively.



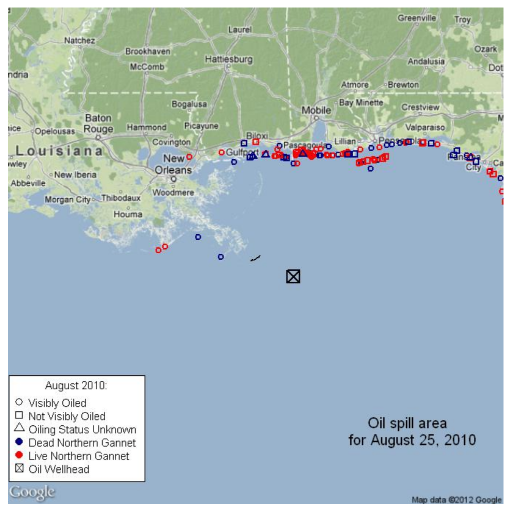
(a) May, 2010



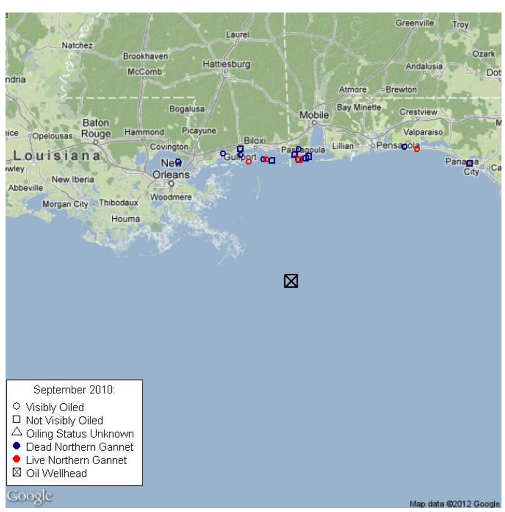
(b) June, 2010



(c) July, 2010



(d) August, 2010



(e) September, 2010

Fig. 30: Northern gannet within months of 2010

3.4 Discussions

The time series of dead and alive bird counts in Figure 15 delivers the very important information that more dead birds were observed than alive ones after the oil spill started. But, this finding might be questioned due to possible confounding factors derived from the observed bird data. In particular, observers may have stated to systematically look for (and report) dead birds while alive birds may not have been reported. Moreover, the time series of dead and alive bird counts by biological orders in Figure 16 shows that the dead birds are higher than the alive ones in most biological orders.

In the bird analysis, we are mainly interested in determining the relationship between the dead bird counts and the oil spill area. We are also interested in identifying any relationships between the oil spill and the observed alive birds with visibly oiled status because these alive birds might not be recovered from oiled coating and might contribute to increase the number of dead birds later.

Figure 17 displays the spatial locations of observed dead and alive birds, as well as the surface oil spill areas within months of 2010. The observations were collected mainly at the Gulf Coast of the United States and a few observations over the water.

A detailed spatio - temporal break down of dead and alive birds with respect to oiling conditions from week 19 (May 3-9, 2010) to week 42 (October 11-17, 2010) is given in Figures 18, 19, 20, and 21. Plots for weeks 19 - 22 (see Figures 18(a), 18(b), 18(c) and 18(d)) shows clearly that the more dead birds were observed, the closer the surface oil spill approaches. Particularly, early dead birds were found in the open water and at the areas closest to the coast of Louisiana in weeks 19 - 20 (see Figures 18(a) and 18(b)). These locations are the closest to the oil wellhead and were reached by the surface oil spill earlier than other coastal locations. This suggests that the oil spill destroyed wild habitat of the shore birds and affected primarily those bird species. In fact, the oil spill affected more northern gannets than laughing gulls and brown pelicans in weeks 19 - 22 of 2010 which covered May 3, 2010 - May 30, 2010. In contrast to laughing gulls and brown pelicans, northern gannets are excellent divers and usually feed in the open waters, far from the coast. Their living habitat was affected by the oil spill before others'. We can see in Figure 30(a) that a few locations of dead northern gannets were in the open sea close to the oil well. Though there was a small number of bird observations right after the oil spill started (see Figure 15), Figure 29 shows more dead northern gannets were observed than alive ones in May 2010. Figures 25 and 27 show that the number of observed dead and alive laughing gulls and brown pelicans in May 2010 was almost the same. But the majority of dead laughing gulls and brown pelicans were observed close to the oil spill areas (see Figures 26(a) and 28(a)), while most alive species were found at the locations far away from the oil.

We can also notice the surface oil spill areas had shifted more towards the coast of Alabama and Florida for weeks 23 - 26 (see Figures 18(e), 18(f), 19(a) and 19(b)). This behaviour of the surface oil spill may be explained by the Loop Current. Figures 13 and 14 show the directions and movements of small currents and the Loop Current. The Loop Current's float could cause a shift of the surface oil spill to Alabama and northwest Florida. With the surface oil spill approaching to the coasts of Alabama and Florida, more dead birds were observed. Figures 25 and 27 that more dead laughing gulls and brown pelicans were observed than alive ones in June 2010. Weeks 23 - 26 aggregated the period from May 31, 2010 to June 27, 2010.

Though the oil wellhead was capped on July 15, 2010, more dead birds were still found at the Gulf coast of the United States. In the plots for later weeks of 2010 (see Figures 19(f), 20, and 21), we can see the dead bird species at the U.S. coast of the Gulf of Mexico. This may be due to the fact that bird species had not been able to recover after oiling wildlife yet.

Figure 22 shows that the Charadriiformes and Pelecaniformes biological orders have the largest size of observed data, while the other biological orders have a relatively small or negligible size of data. We concentrate on the two largest biological orders of bird.

Figure 23 displays the frequencies of Charadriiformes biological order by species, oiling, and living status. The laughing gulls represent the major observed bird data in this order. The dotplot in Figure 25 shows the observed frequencies of laughing gull by months, oiling, and living status after the explosion of the Deepwater Horizon in 2010. The number of dead gulls were found in an increasing manner, i.e., in a smaller number of counts in May and June and in a larger number of counts in July and August. Then a smaller number of dead birds were observed in September. The number of dead observations in October was very small, while the alive laughing gulls were not observed at all. Despite the oil well was capped on July 15, 2010, we can see a large number of dead laughing gulls were observed in July and August of 2010. This may indicate that laughing gulls was suffering badly from the oiled habitat.

Figure 26 shows the spatial locations of dead and alive laughing gulls for the period from May to October 2010. In May, the month after the oil spill started, the dead laughing gulls were mainly observed at the mouth of the Mississippi river which is the closest to the oil wellhead and which was reached by the surface oil spill areas first (see Figure 26(a)). Unfortunately, those dead gulls' oiling conditions were unknown. But a small number of alive gulls were found at the coast of Alabama with not visibly oiled conditions.

Though the oil area sizes were mainly shifted to the coast of northwest Florida, a large number of dead laughing gulls were observed at the Mississippi bays with visibly and not visibly oiled conditions in June (see Figure 26(b)). We can also see that the dead laughing gulls with mainly not visibly oiled conditions were observed at the Mobile bay with approaching the surface oil spill areas.

Figures 26(c), 26(d), and 26(e) show that the majority of dead gulls with visibly and not visibly oiled conditions were found closest to the Mississippi Delta and the coast of Alabama in July, August, and September. These locations were relatively close to the surface oil area. Taking laughing gulls' feeding and breading at and near the coasts into consideration, we may conclude that the laughing gulls and their live habitats were badly affected by the oil spill.

Figure 24 shows the frequencies of Pelecaniformes biological order by species, oiling and living status. We can see that brown pelican and northern gannet bird species have the largest numbers of observations.

Biologists give an explanation why most of the birds recovered have been brown pelicans. The brown pelicans' feeding and breeding behaviours made them very vulnerable to impacts of the oil spill. The observed dead birds at the coast of the Gulf of Mexico may be explained by the coastal habitat of brown pelican. While pelicans are large, and thus are easier to find, many smaller birds harmed by oil may never be found[24].

Figure 27 shows frequencies of brown pelican by months, oiling, and living conditions. The dead brown pelicans were most frequently observed in July and in August of 2010, while the alive pelicans were found mostly in August. Though the oil wellhead was capped on July 15, 2010, a large number of brown pelicans were found dead or alive with visibly oiled conditions in August and September.

Spatial plots (see Figure 28) display that the majority of dead brown pelicans were found at the coast of Louisiana, particularly at the mouth of the Mississippi in May, 2010 (see Figure 28(a)). These locations were mainly habited by coast see birds

[24] `http://www.nytimes.com/interactive/2010/04/28/us/20100428-spill-map.html`

like brown pelicans and they were relatively close to the oil wellhead and therefore took first hits from the oil spill. We can see that the observed dead birds were not visibly oiled and/or oiling conditions were unknown which may suggest that the surface oil area was not close to the shore.

In June 2010 (see Figure 28(b)), we can see that more dead pelicans with visibly oiled conditions were observed at the mouth of the Mississippi. Furthermore, the surface oil area reached to the coast of Alabama and northwest Florida. That may be due to the Loop Current that may have pushed the oil towards the coast. The Figure 14(b) may help to understand directions of currents that are related to the Loop Current in June 2010. The small current arrays at the top of the plot may move the surface oil spill to the coast of Alabama and northwest Florida. The surface oil that reached the coast at regions likely destroyed the habitats of shore birds, like brown pelicans. Figure 28(b) shows that more dead pelicans were found close to Pascagoula and Mobile Bay in Alabama.

Though the Deepwater Horizon oil wellhead was capped on July 15, 2010, dead brown pelicans were still observed at the coast of Louisiana and Alabama in August and September of 2010 (see Figures 28(d) and 28(e), respectively). However, more alive brown pelicans with visibly or not visibly oiled conditions were also found. We can notice from Figures 27 and 28 that the number of dead and alive brown pelicans with not visibly oiled status declined after the capping of the oil wellhead.

Another Pelecaniformes species affected badly from the oil spill in the Gulf of Mexico was the northern gannet. Figure 24 shows that northern gannets were the second mostly observed bird species in the Pelecaniformes biological order.

Figure 29 presents the observed frequencies of northern gannets by months, oiling, and living conditions in the Gulf of Mexico in 2010. We can see that the dead counts of northern gannets, particularly with visibly oiled conditions, were most frequently observed in June, July, and August of 2010. The dead counts climbed fast in June and reached the highest level in July 2010. They started to decrease in August and further declined in September. Alive gannets with visibly oiled conditions were also observed in large quantities in June, July, and August of 2010.

Figure 30(a) for May 2010 shows that the observed dead gannets were observed at the coast of Mississippi, Alabama, and northwest Florida and even close to the oil wellhead which can be explained by northern gannets' feeding behavior over open water. In June (see Figure 30(b)) the surface oil spill area shifted further to the East, which explains the frequent observation of dead and alive northern gannets with visibly and not visibly oiled conditions from these parts of the Gulf. The shift of the surface oil spill area in that direction might be explained by the floating direction of the Loop Current in the Gulf.

In July (see Figure 30(c)) and August (see Figure 30(d)), the dead and alive gannets were observed along entire the coast of Mississippi, Alabama, and northwest Florida. After capping of the oil wellhead in July, the surface oil spill area started to vanish (removed, dispersed and diluted by marine agencies and organizations[25]; disappeared by natural evaporation and dispersal with water[26]; and etc.) and fewer dead birds were found in August (see Figure 30(d)), although still in noticeable quantities. In September, a small amount of dead gannets were observed at the coast near to Biloxi and Pascagoula, as well as close to the Mobile Bay.

Unfortunately, the impact of the Deepwater Horizon oil spill on the Gulf wildlife is impossible to fully estimate due to the birds migrating and breeding behaviour. All bird species, laughing gull, brown pelican, and northern gannet that we studied are migratory birds and have different breeding seasons. Laughing gulls and brown pelicans summer and breed in the Gulf of Mexico, and migrate further south in winter.

[25] `http://www.theenergylibrary.com/node/13342`
[26] `http://gulfseagrant.tamu.edu/oilspill/facts_hurricane.htm`

On the other hand, northern gannets summer and breed in the North Atlantic and only winter in the Gulf of Mexico. The migration of the oiled birds might cause to observe smaller dead numbers in the later months. The destroyed wildlife habitat might also affect the decreasing of bird population in later years.

CHAPTER 4
VISUALIZATION METHODS IN R

4.1 Packages *ggplot2* and *loa*

In addition to the R packages *RgoogleMaps* (Loecher et al., 2012) and *PBSmapping* (Schnute et al., 2012) used in Chapters 2 and 3, two additional geovisualization R packages have been explored for their usefulness for graphically exploring the impact of the Deepwater Horizon oil spill on the Gulf of Mexico. Those packages were *ggplot2* (Wickham, 2009) and *loa* (Ropkins, 2011). Due to some limitations, none of these two packages was used at the final stage when figures in Chapters 2 and 3 were finalised.

4.1.1 Package *ggplot2*

The application of the *ggplot2* package for the visualization of the Deepwater Horizon oil spill was inspired by the work of David Kahle, a former PhD student in Statistics at Rice University, Houston, Texas. He used the *ggplot2* package combined with the *RgoogleMaps* and the *ReadImages* (Loecher, 2012) R packages for the visualization of spatial data of the criminal activity in and around downtown Houston, Texas[1].

We used David Kahle's methods to produce plots for animal data in the Gulf of Mexico. All animal plots were produced in R version 2.13, the latest version at that time. Figure 31 shows a few sample plots that we produced for the fish species observed in 2005 in the Gulf of Mexico. Particularly, Figure 31(a) shows the map of the Mississippi Delta of the Gulf of Mexico, the locations of fish species observed in

[1] `https://github.com/hadley/ggplot2/wiki/Crime-in-Downtown-Houston,-Texas-:-Combining-ggplot2-and-Google-Maps`

2005 (see Figure 31(b)), the contour map (see Figure 31(c)), and weather map (see Figure 31(d)) of those fish locations. R code for Figure 31 can be found in Appendix B.4.1.

Compared to the crime plots in Downtown Houston, the plots in Figure 31 resulted in white lines running horizontally across the maps. An additional search of the technical capabilities of the *ggplot2* package showed that the *ggplot2* package combined with the *RgoogleMaps* package may create some undesired results, such as running white lines, and omitting legends (see Figures 31(b) and 31(c)), and cutting contour lines (see Figure 31(c)) on the zoomed-out google background maps. We found out that the more we zoomed into the background map, the fewer white lines would appear on the map. For example, Figure 44 in Appendix A.1.2 shows only one white line running across the zoomed-in map. If we continued to zoom into the background map until white lines disappeared[2], we would display only a small area of the Gulf. This would not give a comprehensive picture of all animal data observed along the U.S. coast of the Gulf of Mexico. David Kahle was able to produce plots without white lines since he was dealing with a small spatial location as Downtown Houston.

Moreover, we couldn't display the spatial remote sensing data on the background map that was displayed by *RgoogleMaps* in combination with the *ggplot2* package. The technical capacities of the *ggplot2* package did not allow to combine the google background map with the remote sensing polygons.

To get rid of above mentioned defaults, we changed the printing format of the resulting google plots from *jpeg* to *pdf*. Figure 32 shows the *.pdf* version of the fish weather map for the 2005 observations in the Gulf of Mexico. R code for Figure 32 can be found in Appendix B.4.2.

[2] R code manipulation showed that white lines would disappear when longitude coordinates of the map were in the range of 0.05 degrees.

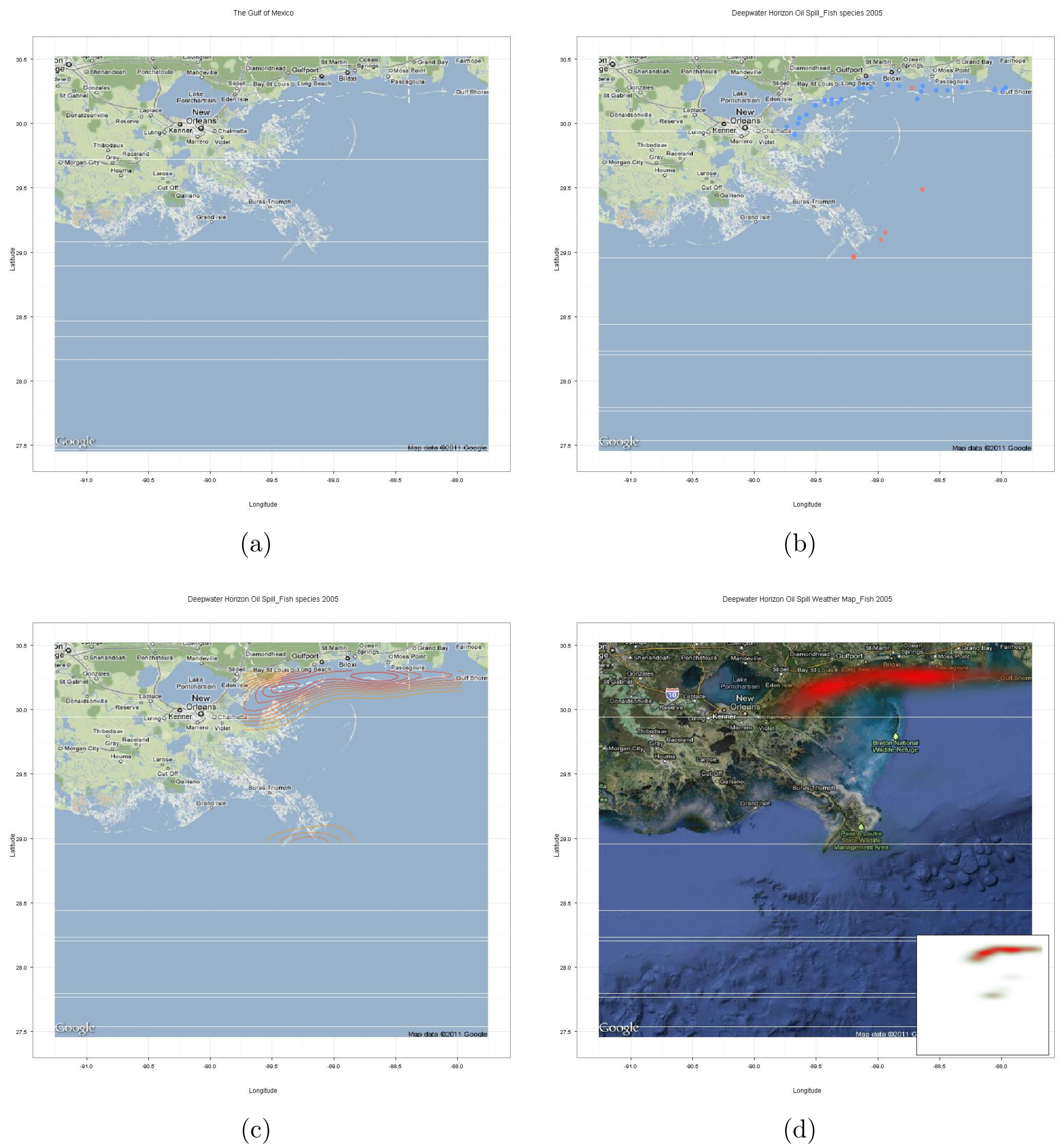


Fig. 31: The observed fish species in 2005 in the Gulf of Mexico. (a) Terrain map of Mississippi Delta, Gulf of Mexico. (b) Fish map for 2005. The blue points represent the locations of white shrimps, whereas the pink points show the locations of atlantic croakers and blue crabs. (c) Fish contour map for 2005. (d) Fish weather map for 2005.

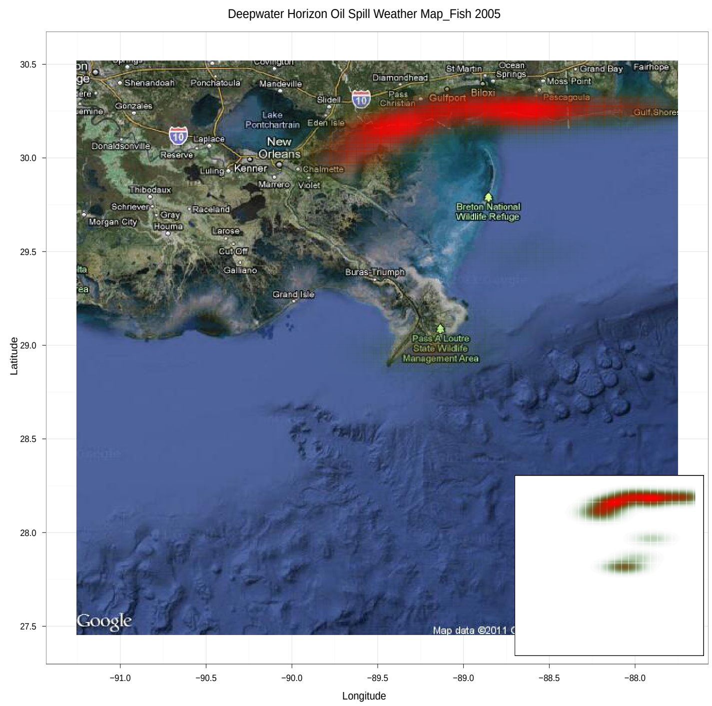
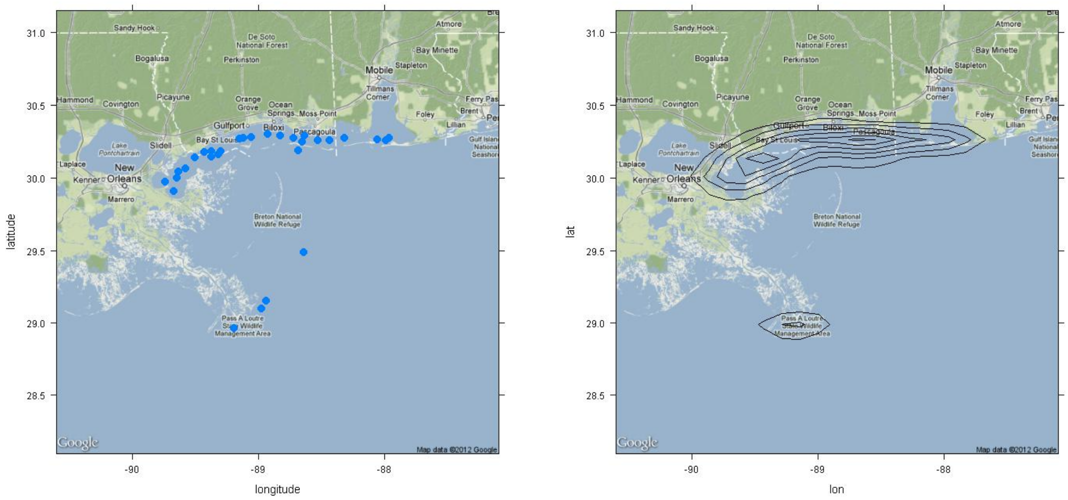


Fig. 32: Fish weather map for 2005 in the Gulf of Mexico

We can see that in Figure 32 the white lines from Figure 31(d) have been removed. Unfortunately, the *.pdf* version of the figure is more blurry than the *.jpeg* version. It is difficult to see the geographical locations in the Gulf of Mexico now. Moreover, the plots produced with the *.pdf* extension have much more bigger sizes than the plots with the *.jpeg* extension. This creates some inconveniences with storing files and incorporating them into a *LaTex* (Lamport, 1984) document. We also could not display the remote sensing data in the *.pdf* format.

Upon the release of R version 2.15 in June 2012[3], we reproduced the *ggplot2* plots again. Unfortunately, the developers of this package have not solved the above mentioned technical problems with capturing larger spatial locations. Moreover, this new version of R is not able to even draw *ggplot2* plots (such as Figures 31 and 32) that we produced with previous versions of R. While the combination of *ggplot2* and

[3] `http://www.r-project.org/`



(a) Fish map for 2005 (b) Fish contour map for 2005

Fig. 33: The observed fish species in 2005 in the Gulf of Mexico

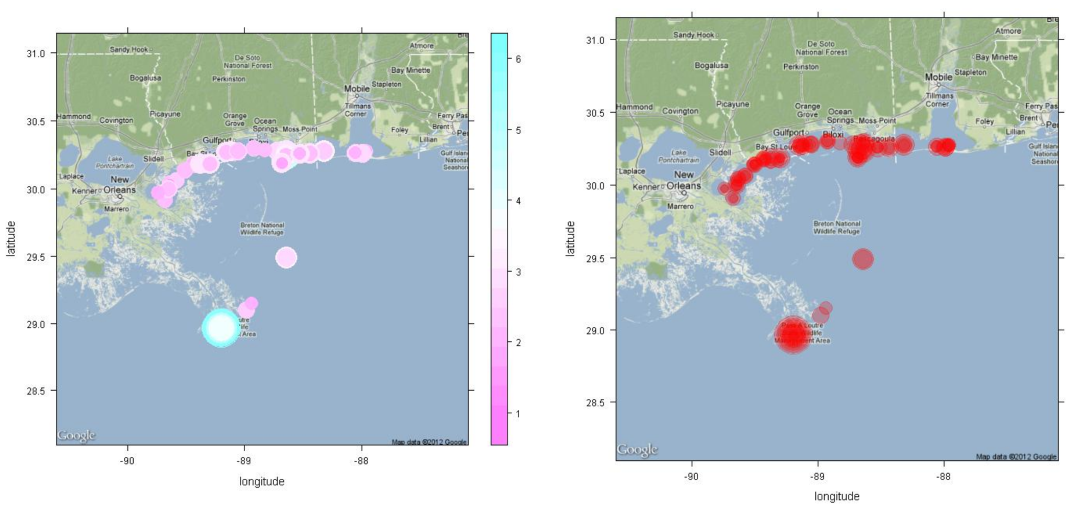
RgoogleMaps shows some very promising potential, some current limitations need to be fixed by the developers of *ggplot2* to make it widely usable for applications similar to those from Chapters 2 and 3.

4.1.2 Package *loa*

Another geovisualization method package in R is a package called *loa*. We experimented with version 0.1.3 that is still in its development stage. It is intended to plot georeferenced data on maps using the *lattice* (Sarkar, 2008) and *RgoogleMaps* R packages.

Figures 33 and 34 were produced by the *loa* package as part of the visualization of the impact of the Deepwater Horizon oil spill on the Gulf. Figure 33(a) displays the locations of fish species observed in 2005 in the Gulf, while Figure 33(b) draws the contour map of fish locations.

Figures 34(a) and 34(b) show the fish species with their NPH toxicity levels. Figure 34(a) explores the technical capacities of *loa* to show spatial data with condi-



(a) (b)

Fig. 34: The observed fish species with their NPH level in 2005 in the Gulf of Mexico. (a) Fish map of NPH levels for 2005 with a scale column. NPH levels are ascending from the smallest pink circles to the largest blue circles. (b) Fish map of NPH levels for 2005. NPH values are changing from the smallest lighter red circles to the largest darker red ones.

tioning, i.e., with NPH levels. The scale from the smallest (pink color) to the largest (blue color) NPH levels is displayed on the right side of the plot. Moreover, the circle sizes show the value of NPH levels, i.e., NPH levels are raising from the smallest pink circles to the largest blue circles. Another way of visualizing toxicity levels is presented in Figure 34(b). NPH levels are changing from the smallest lighter red circles to the largest darker red circles.

Figures 33(a), 34(a), and 34(b) were produced using only the *googleMap* function of *loa*. Here, the *googleMap* function provides lattice-style conditioning/handling for *RgoogleMaps* outputs. Figure 33(b) was created using *googleMap*, *RgoogleMapsWrapper*, and related functions. R code for Figures 33 and 34 can be found in Appendix B.4.3. A modified *RgoogleMaps* output is used as a background image. The map is supplied via *RgoogleMapsWrapper* function which modifies the *RgoogleMaps* output before it is returned to simplify local handling and plotting[4]. The *panel* option in the *googleMap* function was used to generate the plot map and data layers. Please note here that the *googleMap* and related panel handling functions are currently in a development stage and may be subject to change in future releases. Nevertheless, the *loa* package already after some very promising features for applications similar to those from Chapters 2 and 3.

[4] `http://127.0.0.1:28252/library/loa/html/googleMap.html`

4.2 Remote Sensing Data

In this section, we describe our work with remote sensing data, another type of spatial data.

4.2.1 General Background

Schowengerdt (2007) defined: "Remote sensing is the acquisition of information about an object or phenomenon, without making physical contact with the object. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans) by means of propagated signals (e.g. electromagnetic radiation emitted from aircraft or satellites)".

The remote sensing data can consist of discrete point measurements or a profile along a flight path. Here, we are more interested in measurements over a two-dimensional spatial grid, i.e., images. The satellite remote sensing systems provide a repetitive and consistent view of the earth that is invaluable to monitoring short-term and long-term changes and the impact of human activities.

Schowengerdt (2007) listed some fields where remote sensing technology is extensively applied:

- environmental assessment and monitoring (urban growth, hazardous waste);
- global change detection and monitoring (atmospheric ozone depletion, deforestation, global warming);
- agriculture (crop condition, yield prediction, soil erosion);
- non-renewable resource exploration (minerals, oil, natural gas);
- renewable natural resources (wetlands, soils, forests, oceans);

- meteorology (atmosphere dynamics, weather prediction);
- mapping (topography, land use, civil engineering);
- military surveillance and reconnaissance (strategic policy, tactical assessment);
- and news media (illustrations, analysis).

4.2.2 Oil Spill Detection by Satellite Remote Sensing

In our study, we used the remote sensing data obtained from NOAA's Experimental Marine Pollution Surveillance Report (EMPSR) to display the Deepwater Horizon oil spill area in the Gulf of Mexico. The EMPSR was produced by trained satellite analysts in the Satellite Analysis Branch (SAB), within NOAA and National Environment Satellite, Data and Information Service (NESDIS) Office of Satellite Data Processing and Distribution[5].

The NOAA Satellite and Information Service recorded the periodically daily remote sensing data from April 22, 2010, until August 25, 2010. These data are posted on `http://www.ssd.noaa.gov/PS/MPS/deepwater.html`. However, the remote sensing data for several observed days of 2010 are not fully operational and have not been vetted through the usual quality assurance process. In this respect, the SAB Oil Analysis Program analysts advised to use the remote sensing data sets with caution. This is explained by the experimental character of the program. As a reminder, in previous chapter we used the operational remote sensing data from the closest date to replace non-operational data from some specific dates.

SAB analysts manually integrated remote sensing data of the Deepwater Horizon oil spill from numerous imagery sources including Synthetic Aperture Radar (SAR) and high resolution visible imagery along with various ancillary data sources. The

[5] `http://www.ssd.noaa.gov/PS/MPS/deepwater.html`

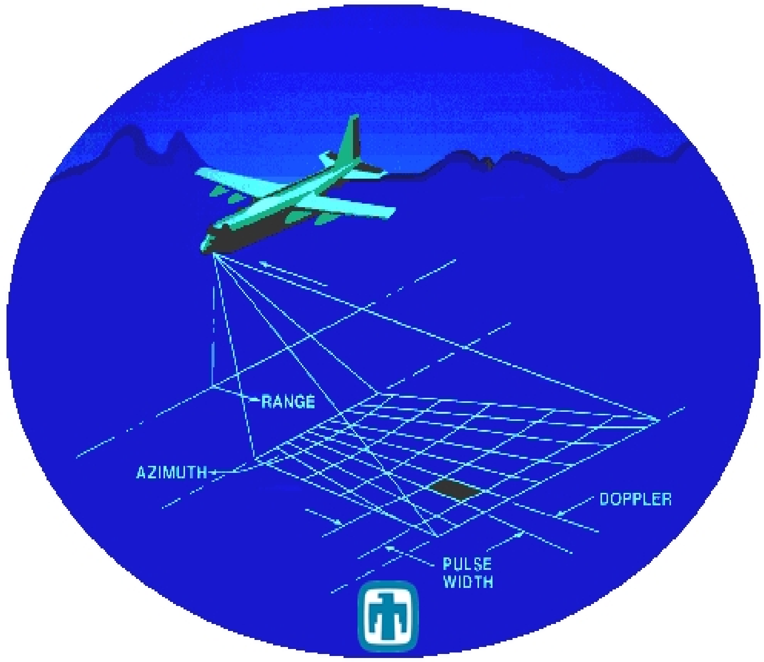


Fig. 35: SAR imaging concept[7]

result is a quality-controlled display of the locations of possible detected oil on the surface of the ocean.

"Synthetic Aperture Radar (SAR) image data provide information different from that of optical sensors operating in the visible and infrared regions of the electromagnetic spectrum. SAR data consist of high-resolution reflected returns of radar-frequency energy from terrain that has been illuminated by a directed beam of pulses generated by the sensor. The radar returns from the terrain are mainly determined by the physical characteristics of the surface features (such as surface roughness, geometric structure, and orientation), the electrical characteristics (dielectric constant, moisture content, and conductivity), and the radar frequency of the sensor. By supplying its own source of illumination, the SAR sensor can acquire data day or night without regard to cloud cover"[6].

[6]http://ciesin.columbia.edu/TG/RS/sarsens.html
[7]http://www.sandia.gov/radar/whatis.html

Figure 35 shows the imaging concept of SAR. Here, we consider an airborne SAR imaging perpendicular to the aircraft velocity. “Typically, SAR produce a two-dimensional (2-D) image. One dimension in the image is called range (or cross track) and is a measure of the ”line-of-sight” distance from the radar to the target. Range is determined by precisely measuring the time from transmission of a pulse to receiving the echo from a target. In the simplest SAR, range resolution is determined by the transmitted pulse width; for example, narrow pulses yield fine range resolution”[7].

“The other dimension is called azimuth (or along track) and is perpendicular to range. It is the ability of SAR to produce relatively fine azimuth resolution that differentiates it from other radars. To obtain fine azimuth resolution, a physically large antenna is needed to focus the transmitted and received energy into a sharp beam. The sharpness of the beam defines the azimuth resolution. Achieving fine azimuth resolution may also be described from a doppler processing viewpoint. A target’s position along the flight path determines the doppler frequency of its echoes: Targets ahead of the aircraft produce a positive doppler offset; targets behind the aircraft produce a negative offset. As the aircraft flies a distance (the synthetic aperture), echoes are resolved into a number of doppler frequencies. The target’s doppler frequency determines its azimuth position”[7].

4.2.3 Visualization of Remote Sensing Data in R

There are many visualization techniques for remote sensing data. Their application depends on the users’ preference and exploitation skills. R has an understandable nature to implement, test and modify satellite image processing techniques easily. The available graphical packages in R make it possible to equally produce outputs as other visualization techniques do (Goslee, 2011).

4.2.3.1 Shapefiles

To display the Deepwater Horizon oil spill area, we read shapefiles obtained from NOAA using R.

A shapefile, often called ESRI shapefile, is a popular geospatial vector data format for GIS software. It is developed and regulated by Environmental Systems Research Institute (ESRI) as a (mostly) open specification for data interoperability among ESRI and other software products (Environmental Systems Research Institute, Inc., 1998).

"The shapefile format is used commonly in GIS. The format was developed by ESRI, and is tied to their Arc View and Arc GIS products. Shapefiles are simple because they store primitive geometrical data type of points, lines, and polygons. These primitives are of limited use without any attributes to specify what they represent. Therefore, a table of records will store properties/ attributes for each primitive shape in the shapefiles. Shapes (points/ lines/ polygons) together with data attributes can create infinitely many representations about geographical data, and depiction provides the ability for powerful and accurate computations" (Yekola et al., 2012).

A shapefile is actually a set of several files. Three individual files are normally mandatory to store the core data that comprises a shapefile. There are several further optional files which store primarily index data to improve performance. A brief explanation of these files is listed below[8]:

Mandatory files:

- ".shp" - shape format; the feature geometry itself
- ".shx" - shape index format; a positional index of the feature geometry to allow seeking forwards and backwards quickly

[8] `http://shapelib.maptools.org/`

- ".dbf" - attribute format; columnar attributes for each shape, in dBase[9] IV format

Optional files:

- ".prj" - projection format; the coordinate system and projection information, a plain text file describing the projection using well-known text format
- ".sbn" and ".sbx" - a spatial index of the features;
- ".fbn" and ".fbx" - a spatial index of the features for shapefiles that are read-only;
- ".ain" and ".aih" - an attribute index of the active fields in a table or a theme's attribute table;
- ".ixs" - a geocoding index for read-write shapefiles;
- ".mxs" - a geocoding index for read-write shapefiles (OpenDocument Database (ODB) format);
- ".atx" - an attribute index for the .dbf file in the form of shapefile.columnname.atx (ArcGIS 8 and later);
- ".shp.xml" - geospatial metadata in XML format, such as ISO 19115 or other schemas;
- ".cpg" - used to specify the code page (only for .dbf) for identifying the character encoding to be used.

"In each of the ".shp", ".shx", and ".dbf" files, the shapes in each file correspond to each other in sequence. That is, the first record in the ".shp" file corresponds to

[9] A popular database management system produced by Ashton Tate Corporation in 1980

the first record in the ".shx" and ".dbf" files, and so on. The ".shp" and ".shx" files have various fields with different endianness[10], so an implementor of the file formats must be very careful to respect the endianness of each field and treat it properly"[11].

Shapefiles deal with coordinates in terms of X and Y, although they are often storing longitude and latitude, respectively. Environmental Systems Research Institute, Inc. (1998) provides more detailed description about the shapefile formats.

4.2.3.2 Read and Write Shapefiles with R

There are several R packages that provide functions for reading and/ or writing shapefiles. Here, we cover only the R packages *rgdal* (Keitt et al., 2012), *maptools* (Lewin-Koh et al., 2012), and *PBSmapping* (Schnute et al., 2012).

The *rgdal* and *maptools* packages depend on the *sp* (Pebesma and Bivand, 2005) package, which defines a set of spatial classes that have become the de facto standard spatial data types in R. The *PBSmapping* packages creates R data objects that are less generally useful, but necessary when calling other analytical functions defined in the package[12].

- Package *rgdal*

  "The *rgdal* package provides an interface to the Geospatial Data Abstraction Library (GDAL), which powers the data import/export capabilities of many geospatially aware software applications. The package includes *readOGR* and *writeOGR* functions for reading and writing shapefiles and other vector-based file formats, respectively. In addition, the *ogrInfo* function is useful for retrieving details about the file without reading in the full dataset"[12].

[10] The term **endianness** refers to the ordering of individually addressable sub-components within the representation of a larger data item as stored in external memory

[11] `http://shapelib.maptools.org/`

[12] `http://www.nceas.ucsb.edu/scicomp/usecases/ReadWriteESRIShapeFiles`

- Package *maptools*

  "The *maptools* package includes a number of useful functions for reading, writing, converting, and otherwise handling spatial objects in R. The general functions for reading and writing shapefiles are *readShapeSpatial* and *writeSpatialShape*, respectively. In both cases, the function automatically determines whether the shapefile contains points, lines, or polygons, and will then read in (or write out) the data using a more specialized function of the particular type. These specialized functions, such as *readShapeLines* for reading lines, can also be called directly. One advantage of doing so is that it will complain if you inadvertently use it on the wrong data type, helping you to catch errors sooner. Unlike their *rgdal* counterparts, the *maptools* functions neither read nor write projection information, leaving it up to you to manage these details manually"[12].

- Package *PBSmapping*

  "The *PBSmapping* package can also read (but not write) shapefiles. However, note that *PBSmapping* uses its own custom-defined spatial data types that are optimized to work with various specialized package functions. This makes it harder to take advantage of functions defined in the numerous packages that are built on *sp*, although the *maptools* package does provide functions that convert between the different formats"[12].

Though all above mentioned packages are similar and produce exactly the same spatial objects (line/polygon), we found *PBSmapping* helpful in adding additional data sets. The functions in this wrapper are easily applied for converting spatial objects (line/polygon) from *sp* classes in *PBSmapping*. Another reason why we preferred

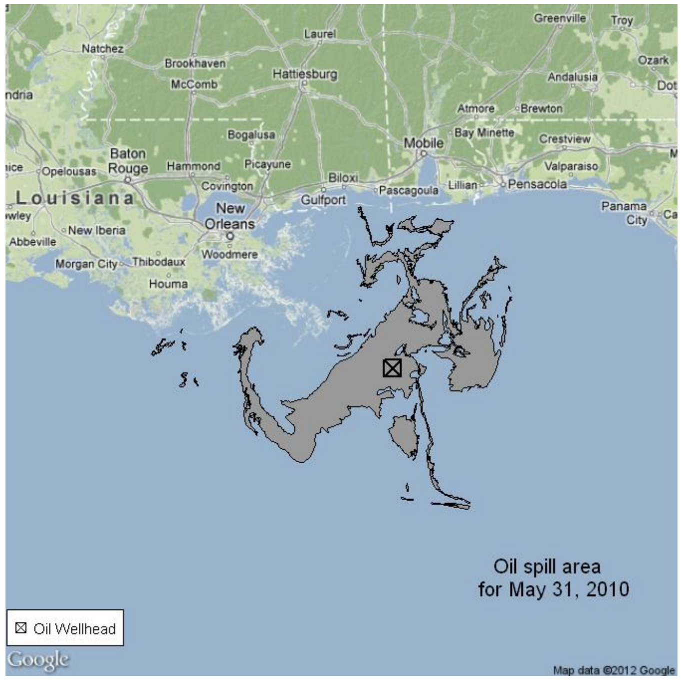


Fig. 36: Deepwater Horizon oil spill in the Gulf of Mexico

PBSmapping to *rgdal* and *maptools* was the relationship of the origin of the *PBSmapping* development to our fish data analysis. *PBSmapping* has evolved from fisheries research conducted at the Pacific Biological Station (PBS) in Nanaimo, British Columbia, Canada. *PBSmapping* extends the R language to include two-dimensional plotting features similar to those commonly available in a GIS.

Figure 36 produces the surface oil spill areas in the Gulf of Mexico for May 31, 2010 with the *PBSmapping* package. R code for Figure 36 can be found in Appendix B.4.4.

A closer look at R code from Appendix B.4.4 reveals how a spatial plot can be created in R from spatial objects containing data from shapefiles.

The first step was to download a static map from the Google server (see Table 11). Here, we demonstrated the use of the *RgoogleMaps* package to download a static Google map image and use it as the background for the R spatial object plot. In fact, the *RgoogleMaps* package is an interface between the R script and the Google

Table 11: Extracted R code from Appendix B.4.4

```
bb = qbbox(c(28, 29, 30), c(-92.2, -87, -85.6), TYPE = "all", margin = list(m = rep(5, 4), TYPE = c("perc", "abs")[1]))

MyMap = GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")
```

Map server. It equips the R program to download static (i.e., non-scrolling) map images from Google Maps, using spatial coordinates and other parameters, and use the images as R plot backgrounds.

The function *qbbox()* in the *RgoogleMaps* package computed a bounding box for the given latitude and longitude points with a few additional options (see Table 11). The wrapper function *GetMap.bbox* of *RgoogleMaps* queried the Google server for a static map tile, defined primarily by its latitude and longitude range.

Table 12: Extracted R code from Appendix B.4.4

```
shpFile = "... .shp"

shp = importShapefile(shpFile, readDBF = TRUE)

PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)
```

Then R code demonstrates a technique using *PBSmapping* for reading and displaying R spatial objects. The function *importShapefile()* in the *PBSmapping* package reads the shapefile obtained from NOAA into R spatial objects (see Table 12). The function *PlotPolysOnStaticMap()* in the *RgoogleMaps* package overlays a polygon that originated from the shapefile onto Google map.

The rest of R code in Appendix B.4.4 is used to overlay the Deepwater Horizon oil spill location and a corresponding legend onto the Google map.

CHAPTER 5

DISCUSSION

The research presented in this report analyses the impact of the Deepwater Horizon oil spill on the wildlife of the Gulf of Mexico. The environmental disaster occurred on April 20, 2010. It left oil spilling for three months until the oil wellhead was capped on July 15, 2010. It is considered the biggest oil spill disaster in North America so far. Its effects on the Gulf wildlife have not been fully understood so far.

Current Research

In this report, we analysed the fish and bird species in the framework of the Deepwater Horizon oil spill. In Chapter 2, our primary study target was the white shrimp species. We dealt with a challenging white shrimp data set with only 10 observations for 2010. We examined white shrimp's PAHs concentration levels within the spatio-temporal break down. We also displayed spatio-temporal locations of white shrimp in relation to the spread of the oil spill. But, our findings based on the available data set showed that the oil spill did not have any negative effect on white shrimp in 2010. Additional data might lead to different findings, but such data were not available for our analysis.

The bird study in Chapter 3, based on the laughing gull, brown pelican, and northern gannet species, shows that the more dead bird species were observed, the closer the surface oil spill area had approached to the Gulf coast, the habitat of these shore birds. The surface oil spill area hit the coast of Louisiana, Mississippi, Alabama, and northwest Florida badly in May and June of 2010. The peak of dead bird observations came in July and August of 2010, when laughing gulls and brown pelicans bred and raised their offspring. The largest number of dead northern gannets were observed in June, July, and August of 2010. Though the majority of northern gannets migrated to the north before the oil spill began, a large number of juvenile gannets were in the Gulf at the time and suffered oil-related mortality. The oil wellhead was capped in mid-July, but bird species were still affected for several weeks thereafter because of their oiled habitats. The migratory behaviour of some bird species did not allow estimating all birds affected by the oil. The observing of a small number of dead birds in later months might be explained by the migrating of laughing gulls and brown pelicans to the south.

Overall, our research comes up with a mixed conclusion about the impact of the oil spill on wildlife. The amount and quality of available fish data does not allow us to show the anticipated oil spill effect on fish habitat. On the other hand, the bird data show a positive association between the number of observed dead birds and the spread of the Gulf oil spill. Thus, the available data do not allow us to draw conclusions about the negative impact of the oil spill on all animal species.

Future Research

To fully understand the oil spill consequences on wildlife, we may need to study third-party data, such as salination and temperature changes, oil clean-up operations, and weather change (hurricanes and tropical storms) in the Gulf of Mexico in combination with the animal data. The oil spill might have caused a decrease of salinity of the ocean water and a cooler fall in fall 2010 followed by a warm winter (Lee and Marcovitz, 2011). This might also result in a diminishing white shrimp population in the Gulf of Mexico. We know from Chapter 2 that white shrimp spawn in warm and salty waters. Furthermore, the rescue organizations used massively chemical dispersants to dissolve and disperse the oil spill which may have increased the pollution of the sea water. Shrimp are more vulnerable to oil and chemical dispersants because they are stationary[1]. Moreover, it would be worthwhile to investigate the effect of hurricanes and tropical storms on the clean-up process and the spreading of the oil spill area in the Gulf[2]. Finally, more comprehensive fish data would be needed to fully determine the oil spill impact on fish. Also, it would be worthwhile to determine whether similar results can be drawn from the available mammal and turtle data that were omitted from this study.

[1] `http://www.nytimes.com/interactive/2010/04/28/us/20100428-spill-map.html`
[2] `http://www.nhc.noaa.gov/2010atlan.shtml`

REFERENCES

G. L. Ambrosini, L. Fritschi, N. H. de Klerk, D. Mackerras, and J. Leavy. Dietary patterns identified using factor analysis and prostate cancer risk: a case control study in Western Australia. *Annals of Epidemiology*, 18(5):364–370, 2008.

B. Armstrong, E. Hutchinson, J. Unwin, and T. Fletcher. Lung cancer risk after exposure to polycyclic aromatic hydrocarbons: a review and meta-analysis. *Environmental Health Perspectives*, 112(9):970–978, 2004.

E. R. Christensen and P. A. Bzdusek. PAHs in sediments of the Black River and the Ashtabula River, Ohio: source apportionment by factor analysis. *Water Research*, 39(4):511–524, 2005.

L. M. Corn and C. Copeland. The deepwater horizon oil spill: Coastal wetland and wildlife impacts and response. *Congressional Research Service*, 7(5700), 2010.

J. L. Domingo, A. Bocio, G. Falcó, and J. M. Llobet. Benefits and risks of fish consumption. Part I. A quantitative analysis of the intake of omega-3 fatty acids and chemical contaminants. *Toxicology*, 230(2-3):219–226, 2007.

Environmental Systems Research Institute, Inc. ESRI shapefile technical description: An esri white paperjuly 1998, 1998. `http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf`.

M. G. Fain and P. Houde. Parallel Radiations in the Primary Clades of Birds. *Evolution*, 58(11), 2004.

G. Falcó, J. L. Domingo, J. M. Llobet, A. Teixidó, C. Casas, and L. Müller. Polycyclic aromatic hydrocarbons in foods: human exposure through the diet in Catalonia, Spain. *Environmental Health Perspectives*, 66(12):2325–2331, 2003.

J. Fox and S. Weisberg. *An R Companion to Applied Regression*. Sage, Thousand Oaks CA, second edition, 2011. URL `http://socserv.socsci.mcmaster.ca/jfox/Books/Companion`.

S. C. Goslee. Analyzing Remote Sensing Data in R: The landsat Package. *Journal of Statistical Software*, 43(4), 2011.

B. Johnson-Restrepo, J. Olivero-Verbel, and S. Lu et al. Polycyclic aromatic hydrocarbons and their hydroxylated metabolites in fish bile and sediments from coastal waters of Colombia. *Environmental Health Perspectives*, 151(3):452–459, 2008.

T. H. Keitt, R. Bivand, E. Pebesma, and B. Rowlingson. *rgdal: Bindings for the Geospatial Data Abstraction Library*, 2012. URL `http://CRAN.R-project.org/package=rgdal`. R package version 0.7-11.

Leslie Lamport. *LaTeX*. LaTeX Project Public License, 1984. URL `www.latex-project.org`.

R. J. Law and J. Hellou. Contamination of fish and shellfish following oil spill incidents. *Environmental Geosciences*, 6(2):90–98, 1999.

B. H. Lee and M. S. Marcovitz. When Oil and Water Mix: Temperature and Salinity Changes in the Gulf after the BP Catastrophe. *Section on Statistical Graphics - JSM 2011*, pages 4656–4664, 2011.

N. J. Lewin-Koh, R. Bivand, contributions by E. J. Pebesma, E. Archer, A. Baddeley, H.-J. Bibiko, J. Callahan, St. Dray, D. Forrest, M. Friendly, P. Giraudoux, D. Golicher, V. G. Rubio, P. Hausmann, K. O. Hufthammer, T. Jagger, S. P. Luque, D. MacQueen, A. Niccolai, T. Short, G. Snow, B. Stabler, and R. Turner. *maptools: Tools for reading and handling spatial objects*, 2012. URL `http://CRAN.R-project.org/package=maptools`. R package version 0.8-14.

T. Li, C. Gao, and M. Xu. Analysis on Deep Water Horizon Oil Spoil by Boosting Tree and Varying Coefficient Logistic Regression. *Section on Statistical Graphics - JSM 2011*, pages 4484–4493, 2011.

M. Loecher. *ReadImages: Image Reading Module for R*, 2012. URL `http://CRAN.R-project.org/package=ReadImages`. R package version 0.1.3.2.

M. Loecher, Berlin School of Economics, and Law. *RgoogleMaps: Overlays on Google map tiles in R*, 2012. URL `http://CRAN.R-project.org/package=RgoogleMaps`. R package version 1.2.0.

H.-B. Moon, K. Kannan, S.-J. Lee, and G. Ok. Atmospheric deposition of polycyclic aromatic hydrocarbons in an urban and a suburban area of Korea from 2002 to 2004. *Archives of Environmental Contamination and Toxicology*, 51(4):494–502, 2006.

T. B. Mowbray. Northern Gannet (*Morus bassanus*), The Birds of North America Online, 2002. `http://bna.birds.cornell.edu/bna/species/693`.

R. J. Muncy. White shrimp. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic). *United States Fish and Wildlife Service*, 82(11):1–19, 1984.

D. E. Nacci, M. Kohan, M. Pelletier, and E. George. Effects of benzo[a]pyrene exposure on a fish population resistant to the toxic effects of dioxin-like compounds. *Aquatic Toxicology*, 57(4):203–215, 2002.

H. K. Ober. Effects of Oil Spills on Marine and Coastal Wildlife. *Wildlife Ecology and Conservation Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida*, 285, 2010.

E. J. Pebesma and R. S. Bivand. Classes and methods for spatial data in R. *R News*, 5(2):9–13, November 2005. URL `http://CRAN.R-project.org/doc/Rnews/`.

Development Core Team R. *A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2012. URL `http://www.R-project.org/`. ISBN 3-900051-07-0.

K. Ropkins. *loa: loa*, 2011. R package version 0.1.3.

M. Rotkin-Ellman and G. Solomon. FDA Risk Assessment of Seafood Contamination after the BP Oil Spill: Rotkin-Ellman and Solomon Respond. Environmental Health Perspectives 120:a55-a56, 2010. `http://ehp03.niehs.nih.gov/article/info%3Adoi%2F10.1289%2Fehp.1104539R`.

D. Sarkar. *Lattice: Multivariate Data Visualization with R*. Springer, New York, 2008. URL `http://lmdvr.r-forge.r-project.org`. ISBN 978-0-387-75968-5.

G. Scherer, S. Frank, K. Riedel, I. Meger-Kossien, and T. Renner. Biomonitoring of exposure to polycyclic aromatic hydrocarbons of nonoccupationally exposed persons. *Cancer Epidemiology Biomarkers and Prevention*, 9(4):373–380, 2000.

J. T. Schnute, N. Boers, and R. Haigh. *PBSmapping: Mapping Fisheries Data and Spatial Analysis Tools*, 2012. URL `http://CRAN.R-project.org/package=PBSmapping`. R package version 2.62.34.

R. A. Schowengerdt. *Remote Sensing: Models And Methods for Image Processing*. Elsevier Inc., Burlington, MA, U.S., 2007.

M. Shen, R. S. Chapman, and X. He et al. Dietary factors, food contamination and lung cancer risk in Xuanwei, China. *Lung Cancer*, 61(3):275–282, 2008.

I. Sioen, J. Van Camp, and F. Verdonck et al. Probabilistic intake assessment of multiple compounds as a tool to quantify the nutritional-toxicological conflict related to seafood consumption. *Chemosphere*, 71(6):1056–1066, 2008.

Smithsonian Marine Station at Fort Pierce. Litopenaeus Setiferus. Field Guide to the Indian River Lagoon, 2011. `http://www.sms.si.edu/IRLFieldGuide/Litopen_setife.htm`.

United States Fish and Wildlife Service. Deepwater Horizon Response Consolidated Fish and Wildlife Collection Report, 2011. `http://www.fws.gov/home/dhoilspill/pdfs/Consolidated%20Wildlife%20Table%2001252011.pdf`.

U. Varanasi, J. E. Stein, and M. Nishimoto. *Biotransformation and disposition of polycyclic aromatic hydrocarbons in fish.* CRC Press, Boca Raton, FL, 1989.

I. Vives, J. O. Grimalt, P. Fernández, and B. Rosseland. Polycyclic aromatic hydrocarbons in fish from remote and high mountain lakes in Europe and Greenland. *Science of the Total Environment*, 324(1-2):67–77, 2004.

G. R. Warnes, B. Bolker, L. Bonebakker, R. Gentleman, W. H. A. Liaw, T. Lumley, M. Maechler, A. Magnusson, S. Moeller, M. Schwartz, and B. Venables. *gplots: Various R programming tools for plotting data*, 2012. URL `http://CRAN.R-project.org/package=gplots`. R package version 2.11.0.

H. Wickham. *ggplot2: elegant graphics for data analysis*. Springer New York, 2009. ISBN 978-0-387-98140-6. URL `http://had.co.nz/ggplot2/book`.

A. Yazdanparast, T. Tran, and E. A. Suess. Effect of Oil Spill on Birds: A Graphical Assay of the Deepwater Horizon Oil Spill's Impact on Birds. *Section on Statistical Graphics - JSM 2011*, pages 5529–5539, 2011.

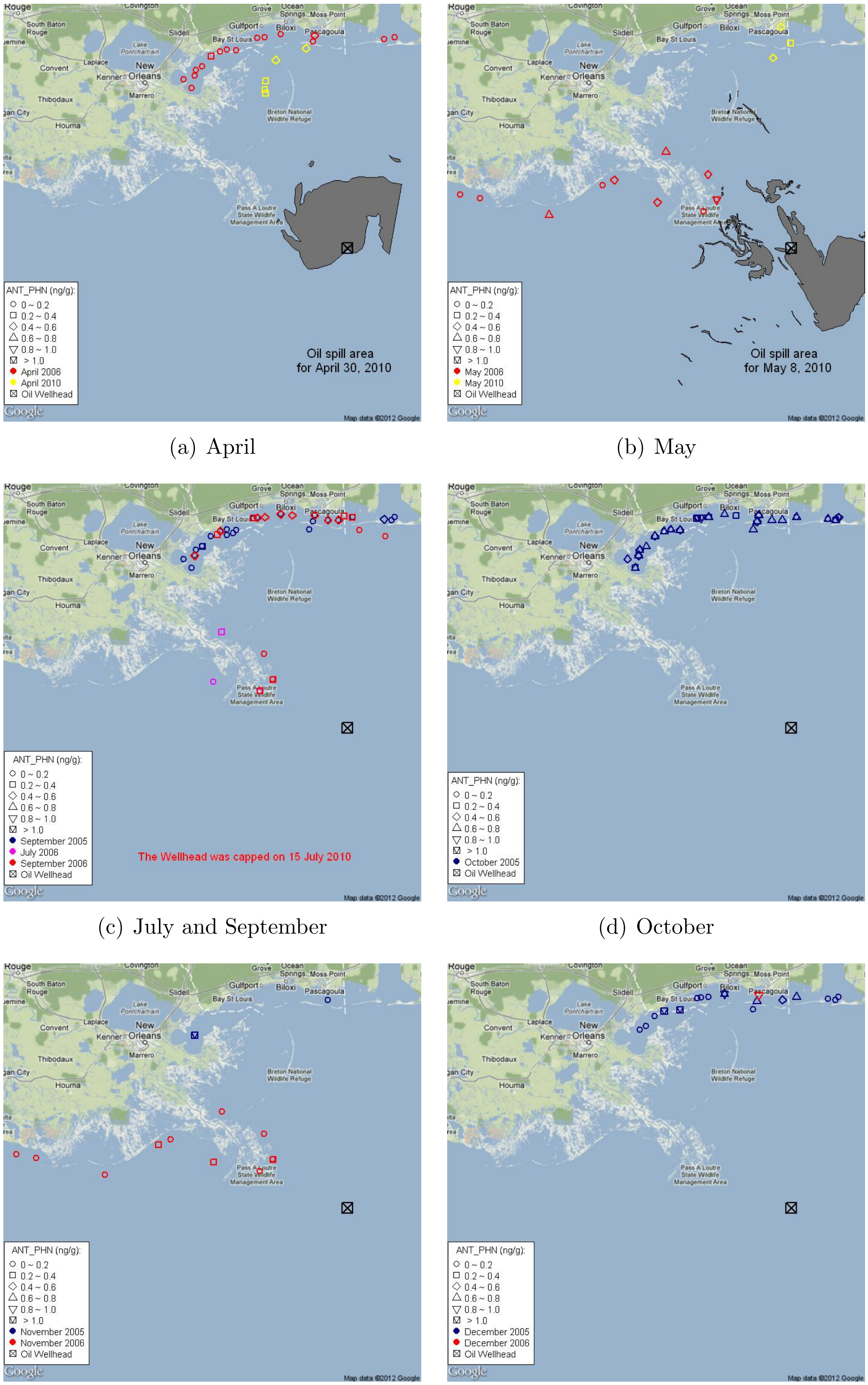
S. R. Yekola, K. Yarrakula, K. Lakshmi Prasad, and T. Madhu. Land Use Planning Using Geographical Information Systems (GIS). *International Journal of Engineering Science and Technology*, 4(05):2167–2175, 2012.

APPENDICES

APPENDIX A
ADDITIONAL PLOTS

A.1 Fishes

A.1.1 Figures of PAHs Components in White Shrimp



(a) April

(b) May

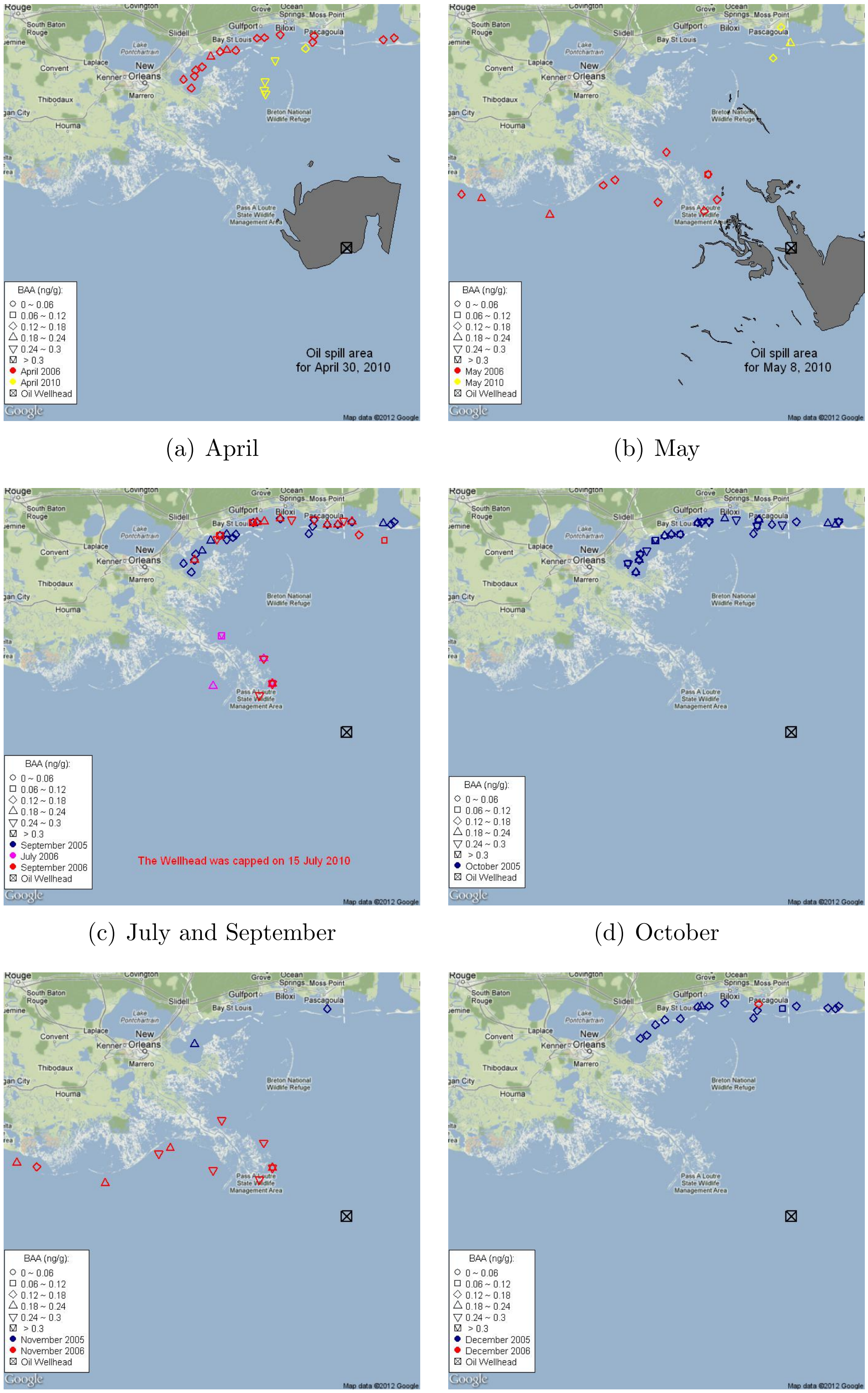
(c) July and September

(d) October

(e) November

(f) December

Fig. 37: ANT/PHN concentration level in white shrimp in 2005, 2006 and 2010

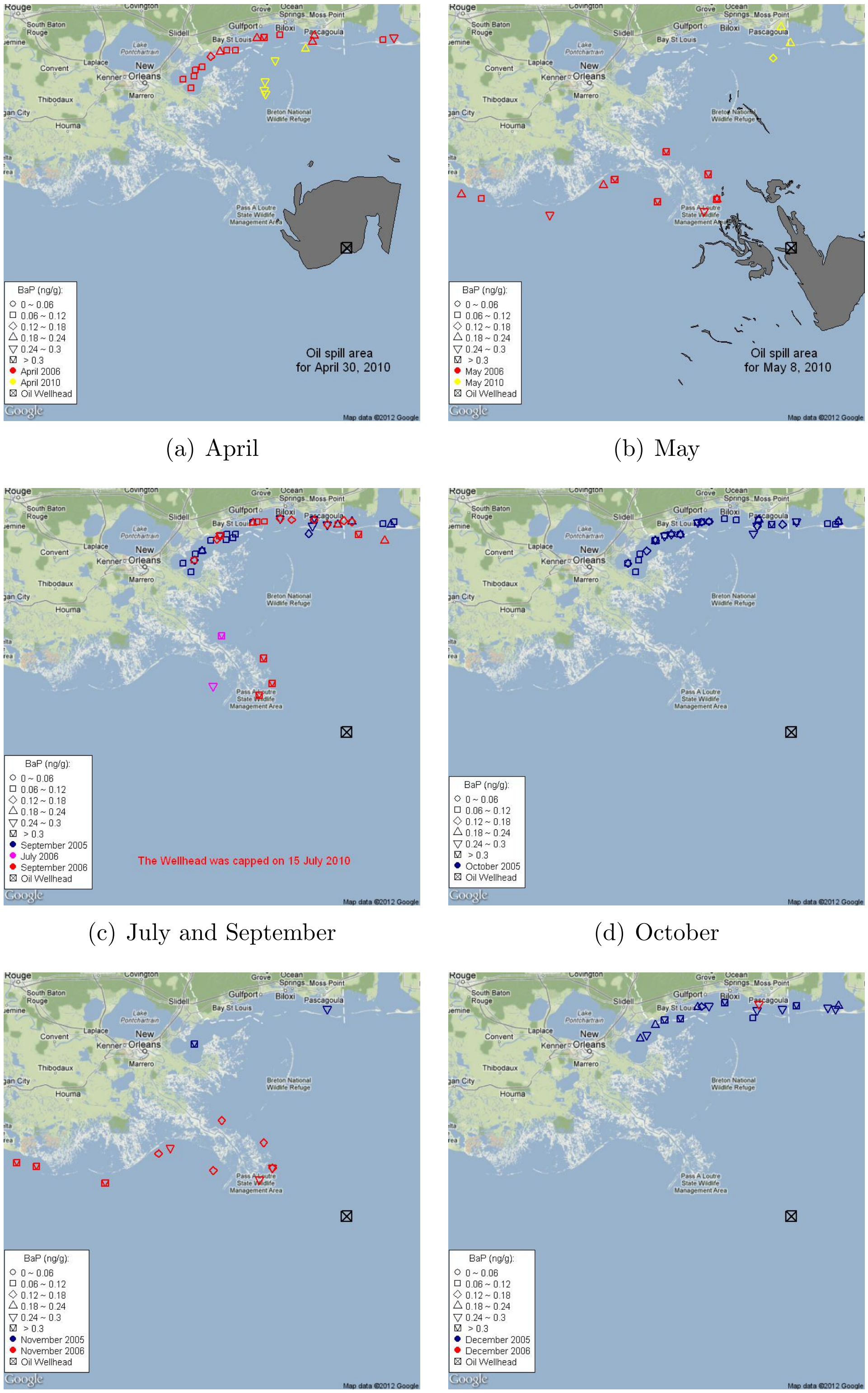


(a) April (b) May

(c) July and September (d) October

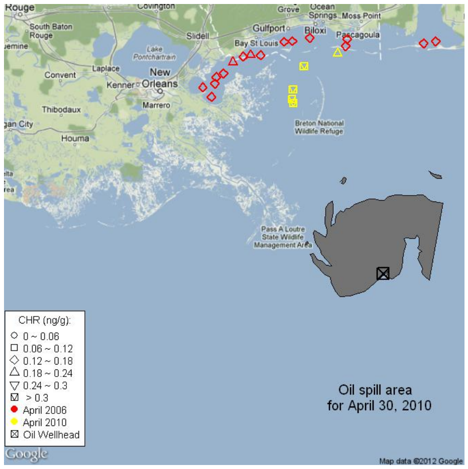
(e) November (f) December

Fig. 38: BAA concentration level in white shrimp in 2005, 2006 and 2010

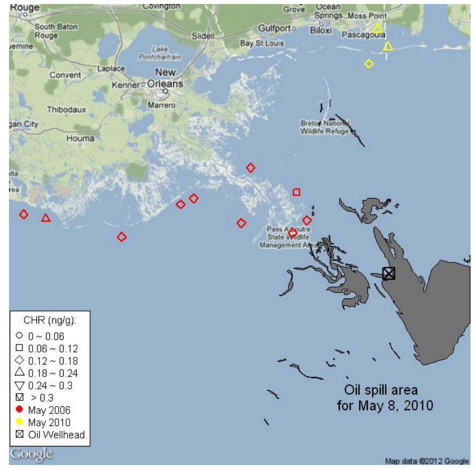


(a) April
(b) May
(c) July and September
(d) October
(e) November
(f) December

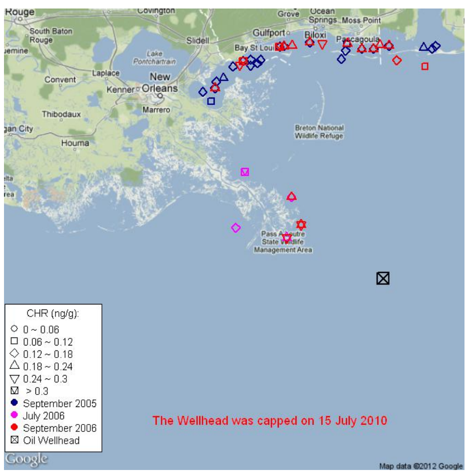
Fig. 39: BaP concentration level in white shrimp in 2005, 2006 and 2010



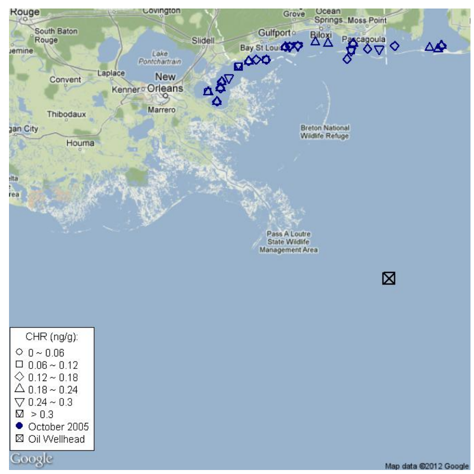
(a) April



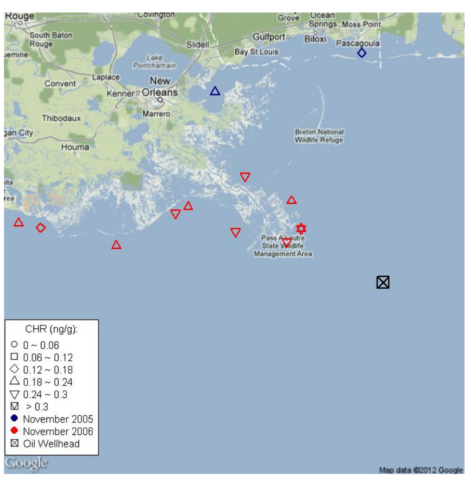
(b) May



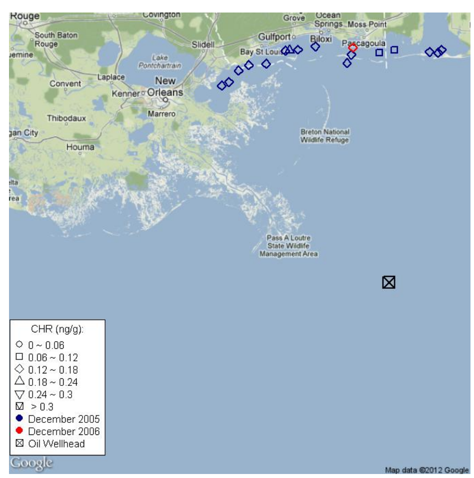
(c) July and September



(d) October

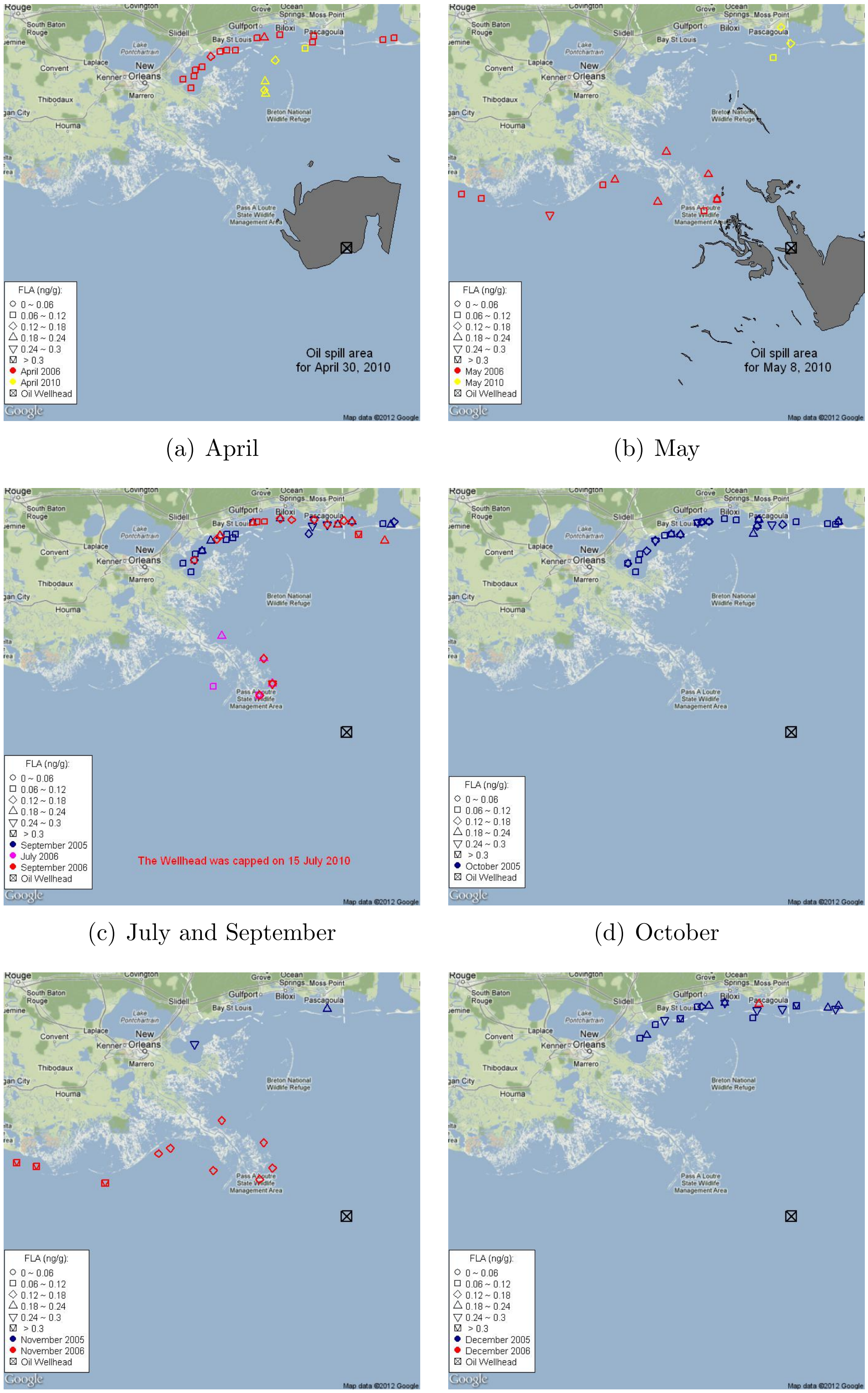


(e) November



(f) December

Fig. 40: CHR concentration level in white shrimp in 2005, 2006 and 2010

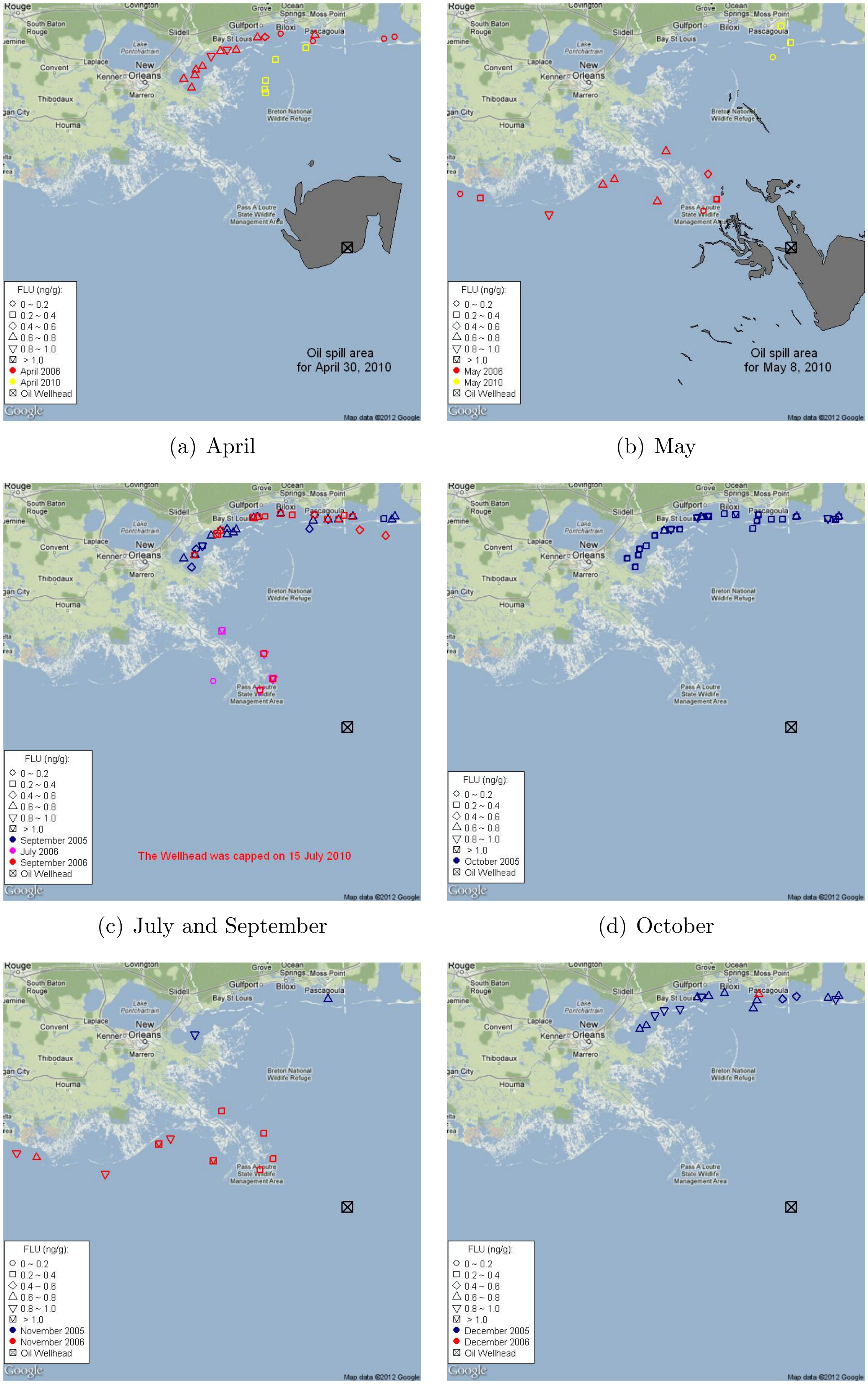


(a) April (b) May

(c) July and September (d) October

(e) November (f) December

Fig. 41: FLA concentration level in white shrimp in 2005, 2006 and 2010



(a) April

(b) May

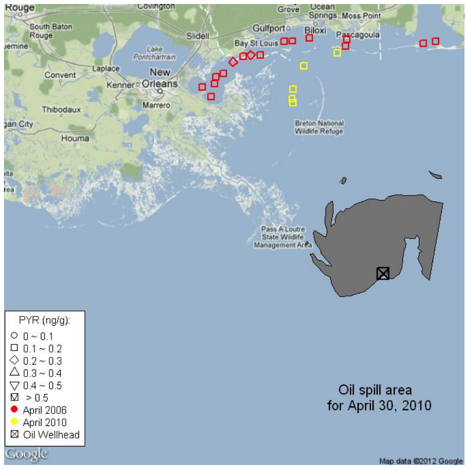
(c) July and September

(d) October

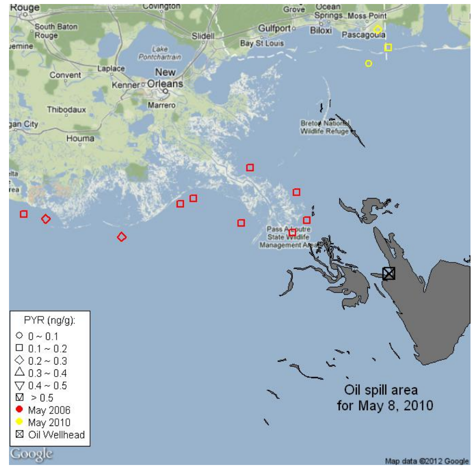
(e) November

(f) December

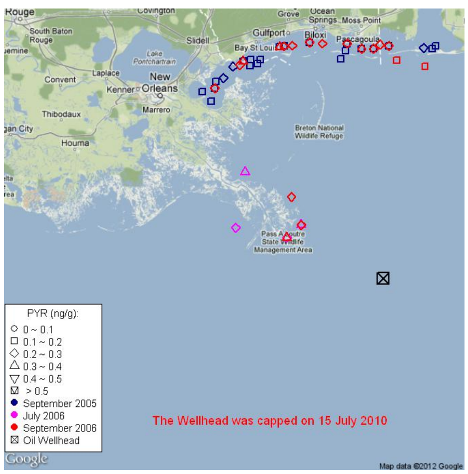
Fig. 42: FLU concentration level in white shrimp in 2005, 2006 and 2010



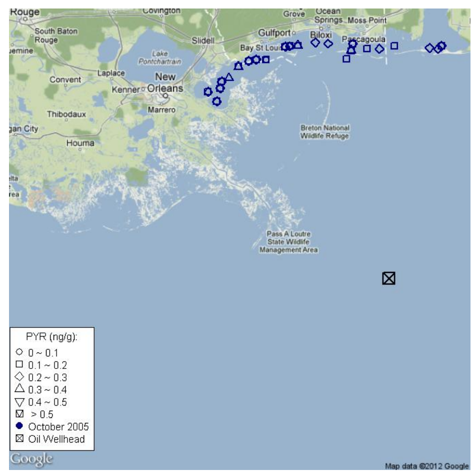
(a) April



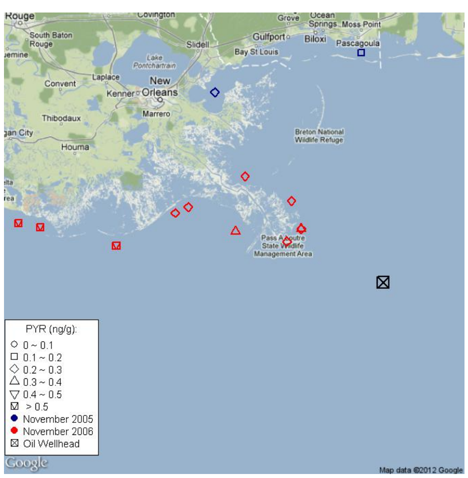
(b) May



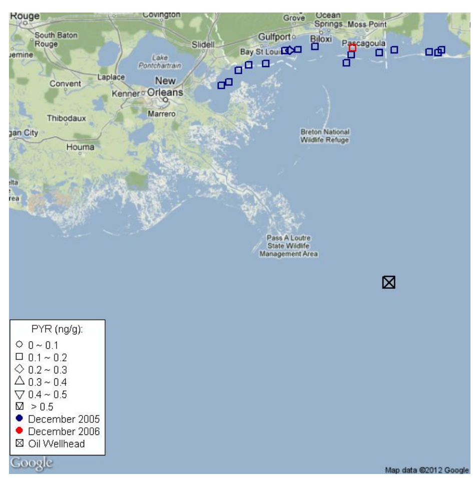
(c) July and September



(d) October



(e) November



(f) December

Fig. 43: PYR concentration level in white shrimp in 2005, 2006 and 2010

A.1.2 Figures of the Deepwater Horizon Oil Spill

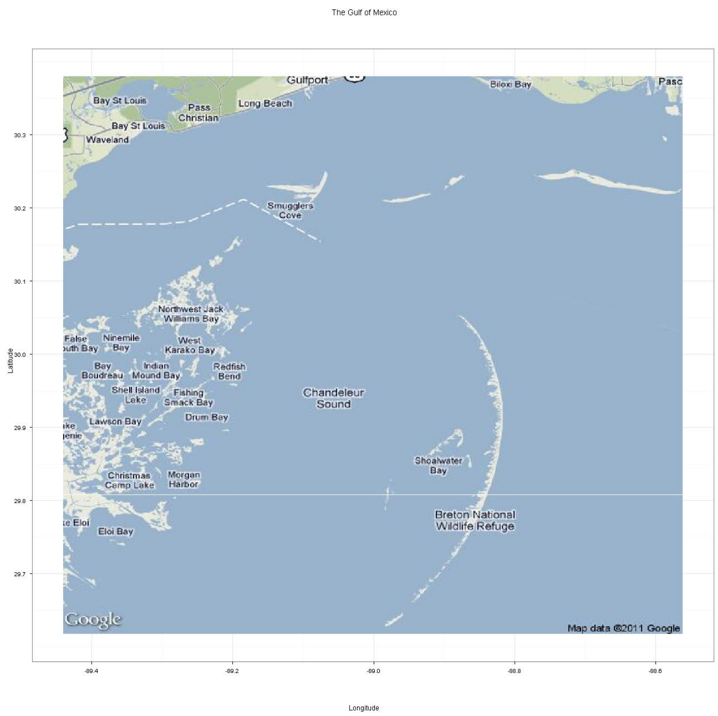


Fig. 44: The Gulf of Mexico

APPENDIX B

R CODE

B.1 R Code for Introduction

B.1.1 R Code for Figure 1

```
pdf("timeline.pdf",width=18, height=8)
par(mar=c(0,1,0,1))
data <-structure(list(eventtime=c(110,112,128,134,146,149,167,191,196,203,214,
216,259,262),impact = c(0.5,-0.5,0.3,-0.25,0.5,-0.5,0.4,-0.25,0.45,-0.6,
0.2,-0.2,0.25,-0.25),label = structure(c(1,2,3,4,5,6,7,8,9,10,11,12,13,14),
.Label = c("Deepwater\n Horizon\n Explosion\n (April 20)",
"\n Discover of\n oil leak\n (April 22)",
"Failure of\n containment\n dome\n (May 8)",
"\n Ineffectiveness of\n insertion tube\n (May 14)",
"Unsuccessful\n 'Top Kill'\n operation\n (May 26)",
"\n LMRP\n Cap Containment\n System operation\n (May 29)",
"The second\n containment system\n operation\n (June 16)",
"\n 'Top Hat Number 10'\n replacement cap\n (July 10)",
"Temporary\n capping of\n the oil leak\n (July 15)",
"\n Leaving the spill\n unsupervised due\n to the storm\n (July 22)",
"'The Static Kill'\n cementing the top\n of the well\n (August 2)",
"\n The well in a\n 'static condition'\n (August 4)",
"'The Bottom Kill'\n pumping of cement\n to seal the well\n (September 16)",
"\n The well is\n 'officially dead'\n (September 19)"),
class = "factor")), .Names = c("eventtime", "impact", "label"),
class = "data.frame", row.names = c(NA, -9))
with(data, {
plot(eventtime, impact, type="h", axes = FALSE, ann=FALSE,
col="black", lty=2, lwd=1.5, ylim=c(-1.0,1.0), xlim=c(95,265))
points(eventtime, impact,pch=95, font=4, cex=2, col=4)
      text(eventtime, impact, label, pos = 1+ 2*(impact > 0),cex=1.1)
   })
abline(h=0,lwd=2)
axis(1, pos=0, lwd=2, lwd.ticks=1, at=c(91,121,152,182,212,243),
lab = (c("April", "May", "June", "July", "August", "September")),cex.axis=1.2)
dev.off()
```

B.2 R Code for Fish

B.2.1 R Code for Reading Fish2005 and Fish2006 Data

```
# Save R code below in your folder as a "fish-baseline.R".
# R code for other figures will refer to it through "source("fish-baseline.R")"

#----------Reading fish-baseline DATA----------#
fish = read.csv(url("http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-baseline.csv"),
sep=",", head = TRUE, as.is=TRUE)

#----------separating data for 2005 and 2006---#
#We will use "if else statement"

Y<-length(fish[,1])
X<-length(fish[1,])

fish.2005<-c()
fish.2006<-c()

for(i in 1:Y){
if(substr(fish[i,4], nchar(fish[i,4]), nchar(fish[i,4])) == "5"){
fish.2005<-rbind(fish.2005, fish[i,])
}
else{
fish.2006<-rbind(fish.2006, fish[i,])
}
}

for(i in 5:X){
fish.2005[,i]<-as.numeric(fish.2005[,i])
fish.2006[,i]<-as.numeric(fish.2006[,i])
}

#---------separating white shrimps for 2005 and 2006---#
white.2005 = fish.2005[(fish.2005[, 1] == "white shrimp"),]
white.2006 = fish.2006[c(fish.2006[, 1] == "white shrimp"),]
```

B.2.2 R Code for Reading Fish2010 Data

```
# Save R code below in your folder as a "fish-june2010.R".
# R code for other figures will refer to it through "source("fish-june2010.R")"
```

```
#--------Reading DATA---------#
fishjune <- read.table(file = "http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-june2010.csv",
header = FALSE, sep = ",", quote = "\"'",
           dec = ".", na.strings = "NA", colClasses = NA, nrows = 45, as.is = TRUE,
           skip = 4, check.names = TRUE, strip.white = FALSE, blank.lines.skip = TRUE,
           comment.char = "#", allowEscapes = FALSE, flush = FALSE,
           fileEncoding = "", encoding = "unknown")

X<-length(fishjune[1,])
Y<-length(fishjune[,1])
#--------Replacing 'No data' by 'NA'---------#
for(i in 1:X){
    for(j in 1:Y){
        if(fishjune[j,i] == "No data"){
           # cat("OK ", j, " ", i,"\n");
            fishjune[j,i] = NA;
        }
    }
}

#-------Converting character to numeric------#
fishjune[,7]<-as.numeric(fishjune[,7])
fishjune[,8]<-as.numeric(fishjune[,8])

#-------Replacing "<" by indicators ---------#
for(i in 10:17){
    t<-rep(1, Y); #indicator
    for(j in 1:45){
        if( grepl("<",fishjune[j,i])){
            t[j] <- 0;
            fishjune[j,i]<-substr(fishjune[j,i], 2, nchar(fishjune[j,i]));
        }
    }
    fishjune[,i]<-as.numeric(fishjune[,i]);
    fishjune<-cbind(fishjune, t)
}
#------------Fish species------------------#
w.shrimp<-c()
oyster<-c()
b.shrimp<-c()
reddrum<-c()
r.snapper<-c()
g.grouper<-c()
w.grouper<-c()
trigger<-c()
v.snapper<-c()
```

```
for(i in 1:Y){
if(substr(fishjune[i,6], 1, 12) == "White shrimp"){
w.shrimp<-rbind(w.shrimp, fishjune[i,])
}
else{
if(substr(fishjune[i,6], 1, 15) == "Atlantic oyster"){
oyster<-rbind(oyster, fishjune[i,])
}
else{
if(substr(fishjune[i,6], 1, 12) == "Brown shrimp"){
b.shrimp<-rbind(b.shrimp, fishjune[i,])
}
else{
if(substr(fishjune[i,6], 1, 8) == "Red drum"){
reddrum<-rbind(reddrum, fishjune[i,])
}
else{
if(substr(fishjune[i,6], 1, 11) == "Red snapper"){
r.snapper<-rbind(r.snapper, fishjune[i,])
}
else{
if(substr(fishjune[i,6], 1, 11) == "Gag grouper"){
g.grouper<-rbind(g.grouper, fishjune[i,])
}

else{
if(substr(fishjune[i,6], 1, 14) == "Warsaw grouper"){
w.grouper<-rbind(w.grouper, fishjune[i,])
}
else{
if(substr(fishjune[i,6], 1, 17) == "Gray trigger fish"){
trigger<-rbind(trigger, fishjune[i,])
}
else{
v.snapper<-rbind(v.snapper, fishjune[i,])
}
}
}
}
}
}

}
}
}
```

B.2.3 R Code for Figure 3

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/4_FISH")

rm(list=ls())

source("fish-baseline.R")

NPH.2005 = white.2005[,7]
FLU.2005 = white.2005[,8]
ANTPHN.2005 = white.2005[,9]
FLA.2005 = white.2005[,10]
CHR.2005 = white.2005[,11]
BaP.2005 = white.2005[,12]
BAA.2005 = white.2005[,13]
PYR.2005 = white.2005[,14]

NPH.2006 = white.2006[,7]
FLU.2006 = white.2006[,8]
ANTPHN.2006 = white.2006[,9]
FLA.2006 = white.2006[,10]
CHR.2006 = white.2006[,11]
BaP.2006 = white.2006[,12]
BAA.2006 = white.2006[,13]
PYR.2006 = white.2006[,14]

# April and May of 2006
NPH.AprMay.2006 = c( NPH.w.shrimp.april.2006, NPH.w.shrimp.may.2006 )
FLU.AprMay.2006 = c( FLU.w.shrimp.april.2006, FLU.w.shrimp.may.2006 )
ANTPHN.AprMay.2006 = c( ANTPHN.w.shrimp.april.2006, ANTPHN.w.shrimp.may.2006 )
FLA.AprMay.2006 = c( FLA.w.shrimp.april.2006, FLA.w.shrimp.may.2006 )
CHR.AprMay.2006 = c( CHR.w.shrimp.april.2006, CHR.w.shrimp.may.2006 )
BaP.AprMay.2006 = c( BaP.w.shrimp.april.2006, BaP.w.shrimp.may.2006 )
BAA.AprMay.2006 = c( BAA.w.shrimp.april.2006, BAA.w.shrimp.may.2006 )
PYR.AprMay.2006 = c( PYR.w.shrimp.april.2006, PYR.w.shrimp.may.2006 )


source("fish-june2010.R")

NPH.2010 = w.shrimp[,10] # 18
FLU.2010 = w.shrimp[,11]
ANTPHN.2010 = w.shrimp[,12]
FLA.2010 = w.shrimp[,13]
CHR.2010 = w.shrimp[,16]
BaP.2010 = w.shrimp[,17]
BAA.2010 = w.shrimp[,15] # 15
PYR.2010 = w.shrimp[,14] # 14
```

```
#----------------------Dot-Box-Plots-------------------#
pdf(file = "dot-box_AprMay_vs_general.pdf",width=16,height=14,pointsize = 12,bg = "white")

m <- matrix(c(1,2,3,4,5,6,7,8,9,9,9,9),nrow = 3,ncol = 4,byrow = TRUE)
layout( mat = m, heights = c(0.3,0.3,0.075) )

#-----ANTPHN------#
par(mar = c(3,5,2,2), cex.main = 1.7, cex.axis=1.7, cex.lab=2.3)
boxplot(ANTPHN.2005,ANTPHN.2006,ANTPHN.2010, xaxt="na", ylab="(in ng/g)")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="ANTPHN")

# April/May of 2006
points(rep(2, length(ANTPHN.AprMay.2006)), ANTPHN.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
if(w.shrimp[i,20]==1){
points(3, w.shrimp[i,12], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,12], pch = 21, col="blue", cex=1.5);
}
}


#-----BAA------#
par(mar = c(3,3,2,2), cex.main = 1.7, cex.axis=1.7)
boxplot(BAA.2005,BAA.2006,BAA.2010, xaxt="na")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="BAA")

# April/May of 2006
points(rep(2, length(BAA.AprMay.2006)), BAA.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
if(w.shrimp[i,23]==1){
points(3, w.shrimp[i,15], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,15], pch = 21, col="blue", cex=1.5);
}
}


#-----BaP------#
```

```
par(mar = c(3,3,2,2), cex.main = 1.7, cex.axis=1.7)
boxplot(BaP.2005,BaP.2006,BaP.2010, xaxt="na")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="BaP")

# April/May of 2006
points(rep(2, length(BaP.AprMay.2006)), BaP.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
if(w.shrimp[i,25]==1){
points(3, w.shrimp[i,17], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,17], pch = 21, col="blue", cex=1.5);
}
}



#-----CHR------#
par(mar = c(3,3,2,2), cex.main = 1.7, cex.axis=1.7)
boxplot(CHR.2005,CHR.2006,CHR.2010, xaxt="na")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="CHR")

# April/May of 2006
points(rep(2, length(CHR.AprMay.2006)), CHR.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
if(w.shrimp[i,24]==1){
points(3, w.shrimp[i,16], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,16], pch = 21, col="blue", cex=1.5);
}
}



#-----FLA------#
par(mar = c(3,5,2,2), cex.main = 1.7, cex.axis=1.7, cex.lab=2.3)
boxplot(FLA.2005,FLA.2006,FLA.2010, xaxt="na", ylab="(in ng/g)")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="FLA")

# April/May of 2006
points(rep(2, length(FLA.AprMay.2006)), FLA.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
```

```
if(w.shrimp[i,21]==1){
points(3, w.shrimp[i,13], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,13], pch = 21, col="blue", cex=1.5);
}
}


#-----FLU------#
par(mar = c(3,3,2,2), cex.main = 1.7, cex.axis=1.7)
boxplot(FLU.2005,FLU.2006,FLU.2010, xaxt="na")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="FLU")

# April/May of 2006
points(rep(2, length(FLU.AprMay.2006)), FLU.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
if(w.shrimp[i,19]==1){
points(3, w.shrimp[i,11], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,11], pch = 21, col="blue", cex=1.5);
}
}


#-----NPH------#
par(mar = c(3,3,2,2), cex.main = 1.7, cex.axis=1.7)
boxplot(NPH.2005,NPH.2006,NPH.2010, xaxt="na")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="NPH")

# April/May of 2006
points(rep(2, length(NPH.AprMay.2006)), NPH.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
if(w.shrimp[i,18]==1){
points(3, w.shrimp[i,10], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,10], pch = 21, col="blue", cex=1.5); # less sign value
}
}
```

```
#-----PYR------#
par(mar = c(3,3,2,2), cex.main = 1.7, cex.axis=1.7)
boxplot(PYR.2005,PYR.2006,PYR.2010, xaxt="na")
axis(side = 1, at=c(1,2,3), labels = c("2005", "2006", "2010"))
title(main="PYR")

# April/May of 2006
points(rep(2, length(PYR.AprMay.2006)), PYR.AprMay.2006, col="blue", pch=3)

for(i in 1:length(w.shrimp[,1])){
if(w.shrimp[i,22]==1){
points(3, w.shrimp[i,14], pch = 3, col="blue", cex=1.5);
}
else{
points(3, w.shrimp[i,14], pch = 21, col="blue", cex=1.5);
}
}

plot(1, type = "n", axes=FALSE, xlab="", ylab="")
legend( x = "top", inset = 0,
        legend = c("Exact value", "Might be a smaller value"),
        title = "Observations collected in April and May:",
col=c("blue", "blue"), lty=c(0,0,0), pch=c(3, 21), cex=1.7, horiz = TRUE )

dev.off()
```

B.2.4 R Code for Figures 4 and 5

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/4_FISH")

rm(list=ls())

library(ggplot2)
library(reshape)
library(scales)

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

library(gplots) # to read.xls

# ------------------- White Shrimps for 2010 ------------------------------ #
source("fish-june2010.R")
```

```
w.shrimp.2010 = cbind( w.shrimp[,9], w.shrimp[,7:8], w.shrimp[,10:17] )
colnames(w.shrimp.2010) <- c( "Date","Latitude","Longitude","NPH",
"FLU","ANT/PHN","FLA","PYR","BAA","CHR","BaP" )


source("fish-baseline.R")
# ------------------- White Shrimps for 2005 ------------------------------ #
w.shrimp.2005 = cbind( white.2005[,4:6], white.2005[,7:14] )
# reorder toxicity columns like 2010's
w.shrimp.2005 = cbind( w.shrimp.2005[,1:7], w.shrimp.2005[,11],
w.shrimp.2005[,10], w.shrimp.2005[,8:9] )
colnames(w.shrimp.2005) <- c( "Date","Latitude","Longitude","NPH","FLU",
"ANT/PHN","FLA","PYR","BAA","CHR","BaP" )

# ------------------- White Shrimps for 2006 ------------------------------ #
# Delete the outliers:
for( i in 1:length( white.2006[,1] ) ){
if( white.2006$PYR[i] == 2.8 ){ # 1 outlier
white.2006$PYR[i] = NA
}
if( white.2006$BaP[i] == 0.530 ){ # 1 outlier
white.2006$BaP[i] = NA
}
if( white.2006$CHR[i] >= 0.66 ){ # 3 outliers
white.2006$CHR[i] = NA
}
}

w.shrimp.2006 = cbind(white.2006[,4:6], white.2006[,7:14] )

# reorder toxicity columns like 2010's
w.shrimp.2006 = cbind( w.shrimp.2006[,1:7], w.shrimp.2006[,11],
w.shrimp.2006[,10], w.shrimp.2006[,8:9] )
colnames(w.shrimp.2006) <- c( "Date","Latitude","Longitude","NPH","FLU",
"ANT/PHN","FLA","PYR","BAA","CHR","BaP" )

#### Combine all data
w.shrimp = rbind( w.shrimp.2005, w.shrimp.2006, w.shrimp.2010 )

# change the order of columns (avoid unnumeric column caused by removing outliers)numric)
w.shrimp = cbind( w.shrimp[,1:8], w.shrimp[,10:11], w.shrimp[,9] )
colnames(w.shrimp) <- c( "Date","Latitude","Longitude","NPH","FLU",
"ANT/PHN","FLA","PYR","CHR","BaP","BAA" )

# reorder the rows from the newest to oldest
#write.table( w.shrimp, file="w.shrimp_general.csv", sep=",", row.names=F )
```

```
w.shrimp = read.xls('w.shrimp_general.xlsx')

# keep the latitudes and longitudes
w.shrimps.loc = cbind( w.shrimp[,1:4] )

w.shrimp = cbind( w.shrimp[,c(1,5:12)] )

# ============================ heat map ====================================#
temp.names<-w.shrimp[,1]
w.shrimp<-w.shrimp[,-1]

w.shrimp<-as.matrix(w.shrimp, row.names=NULL)
rownames(w.shrimp)<-c(as.character(temp.names))

# scale data to mean=0, sd=1 and convert to matrix
w.shrimp_scaled <- as.matrix( scale( w.shrimp, center = TRUE, scale = TRUE ) )

# If center is TRUE then centering is done by subtracting the column means
# (omitting NAs) of "w.shrimp" from their corresponding columns, and
# if center is FALSE, no centering is done.

# If scale is TRUE then scaling is done by dividing the (centered) columns of
# "w.shrimp" by their standard deviations if center is TRUE, and
# the root mean square otherwise. If scale is FALSE, no scaling is done.

# Colorbrewer's choices:  http://colorbrewer2.org/
# diverging, number of data classes = 8, turn on a colorblind safe
mypalette <- brewer.pal(8,"RdBu")

pdf(file = "cluster_heatmap_general(a).pdf",width=15,height=17,pointsize = 12,bg = "white")
hv <- heatmap.2(w.shrimp_scaled, col=mypalette, scale="column",
margin=c(7, 7), cexRow= 0.6,
xlab = "Toxicities", ylab= "Dates and Locations",
main='White shrimps in 2005, 2006 and 2010',
# level trace
tracecol="red",
# color key and density info
key = TRUE, keysize = 1.0, densadj = 0.25, density="density")
dev.off()

# cluster rows
#hc.rows <- hclust( dist( w.shrimp_scaled ) )
#plot( hc.rows )

# transpose the matrix and cluster columns
#hc.cols <- hclust( dist( t( w.shrimp_scaled ) ) )
#plot( hc.cols )
```

```
# ============================ Rgooglemap ====================================#
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

jpeg("cluster_heatmap_general(d).jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# locations for 2005
MyMap2 = PlotOnStaticMap( MyMap, w.shrimps.loc[83:170,3], w.shrimps.loc[83:170,4],
FUN = points, lwd=2, pch=0, cex=1.6, col = "yellow", add = T )

# locations for 2006
MyMap3 = PlotOnStaticMap( MyMap2, w.shrimps.loc[11:82,3], w.shrimps.loc[11:82,4],
FUN = points, lwd=2, pch=2, cex=1.6, col = "darkmagenta", add = T )

# locations for 2010 (L1,L2,L3,L4,L5,L6,L7,L8)
MyMap4 = PlotOnStaticMap( MyMap3, w.shrimps.loc[1:10,3], w.shrimps.loc[1:10,4],
FUN = points, lwd=2, pch=1, cex=1.8, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.5,
legend = c( "Locations 2005 ", "Locations 2006", "Locations 2010",
"Oil Wellhead" ),  pch=c( 0,2,1,7 ),
col = c("yellow","darkmagenta","red","black"),
title="White Shrimp:", cex=1.3, bg="skyblue" )

dev.off()
```

B.2.5 R Code for Figure 6

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)
```

```
source("fish-june2010.R")

bb <- qbbox(c(28,29,30), c(-91.0,-89,-87.5), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")


# ================= April 30
jpeg("OilSpillAreas_Apr30.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray50", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# locations for April 30, 2010
MyMap2 = PlotOnStaticMap( MyMap, w.shrimp.april_30.2010[,7], w.shrimp.april_30.2010[,8],
FUN = points, lwd=2, pch=1, cex=1.8, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.63,
legend = c( "April 30, 2010", "Oil Wellhead" ),  pch=c( 1,7 ),
col = c("red","black"), title="White Shrimp Locations:", cex=1.3, bg="skyblue" )

text( 225, -250, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ================= May 1
jpeg("OilSpillAreas_May01.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 01
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100501_1640\\20100429_2152_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray50", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )
```

```
# locations for May 1, 2010
MyMap2 = PlotOnStaticMap( MyMap, w.shrimp.may_01.2010[,7], w.shrimp.may_01.2010[,8],
FUN = points, lwd=2, pch=1, cex=1.8, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.63,
legend = c( "May 1, 2010", "Oil Wellhead" ),  pch=c( 1,7 ),
col = c("red","black"), title="White Shrimp Locations:", cex=1.3, bg="skyblue" )

text( 225, -250, "Oil spill area \n for May 1, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ================= May 2
jpeg("OilSpillAreas_May02.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 02
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100502_0351\\20100502_0351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray50", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# locations for May 2, 2010
MyMap2 = PlotOnStaticMap( MyMap, w.shrimp.may_02.2010[,7], w.shrimp.may_02.2010[,8],
FUN = points, lwd=2, pch=1, cex=1.8, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.63,
legend = c( "May 2, 2010", "Oil Wellhead" ),  pch=c( 1,7 ),
col = c("red","black"), title="White Shrimp Locations:", cex=1.3, bg="skyblue" )

text( 225, -250, "Oil spill area \n for May 2, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ================= May 6
# Locations are unknown and the oil spill area for 2010 ?
```

```
# ================= May 7
jpeg("OilSpillAreas_May07.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray50", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# locations for May 7, 2010
MyMap2 = PlotOnStaticMap( MyMap, w.shrimp.may_07.2010[,7], w.shrimp.may_07.2010[,8],
FUN = points, lwd=2, pch=1, cex=1.8, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.63,
legend = c( "May 7, 2010", "Oil Wellhead" ),  pch=c( 1,7 ),
col = c("red","black"), title="White Shrimp Locations:", cex=1.3, bg="skyblue" )

text( 225, -250, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```

B.2.6 R Code for Figures 37, 38, 39, 40, 41, 42, 7, and 43

B.2.6.1 R Code For Figure 37

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.2; u2=0.4; u3=0.6; u4=0.8; u5=1.0

# ======================== April 2006 and April 2010 ======================== #
jpeg("wshrimp_googlemap_ANT_PHN_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = ANT_PHN # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
```

```
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# ---------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = ANT_PHN # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()
```

```
for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="ANT_PHN (ng/g):")

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```

```
# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_ANT_PHN_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}
```

```
# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# --------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = ANT_PHN # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
```

```
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="ANT_PHN (ng/g):")

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ================== September 2005, July and September 2006 ================ #
jpeg("wshrimp_googlemap_ANT_PHN_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
```

```
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
```

```
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# --------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
```

```
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
bg="white", title="ANT_PHN (ng/g):")
```

```
text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_ANT_PHN_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- October of 2005
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}
```

```
# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7), pt.cex=1.5,
bg="white", title="ANT_PHN (ng/g):")

dev.off()


# ==================== November 2005 and November 2006 =============== #
jpeg("wshrimp_googlemap_ANT_PHN_nov.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
```

```
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
```

```
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="ANT_PHN (ng/g):")

dev.off()


# ==================== December 2005 and December 2006 =============== #
jpeg("wshrimp_googlemap_ANT_PHN_dec.jpg", width=7.5, height=7.5, units="in", res=90)
```

```
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
```

```
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- December of 2006 ------------------------------ #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = ANT_PHN # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
```

```
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="ANT_PHN (ng/g):")

dev.off()
```

B.2.6.2 R Code For Figure 38

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.06; u2=0.12; u3=0.18; u4=0.24; u5=0.3

# ========================= April 2006 and April 2010 ========================= #
jpeg("wshrimp_googlemap_BAA_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
```

```
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = BAA # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
```

```
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# --------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = BAA # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
```

```
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BAA (ng/g):")

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_BAA_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# ---------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = BAA # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
```

```
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BAA (ng/g):")

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ================== September 2005, July and September 2006 =============== #
```

```
jpeg("wshrimp_googlemap_BAA_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
```

```
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
```

```
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# --------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
```

```
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
bg="white", title="BAA (ng/g):")

text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_BAA_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- October of 2005
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
```

```
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7), pt.cex=1.5,
bg="white", title="BAA (ng/g):")

dev.off()


# ==================== November 2005 and November 2006 =============== #
jpeg("wshrimp_googlemap_BAA_nov.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
```

```
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
```

```
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
```

```
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BAA (ng/g):")

dev.off()


# ==================== December 2005 and December 2006 =============== #
jpeg("wshrimp_googlemap_BAA_dec.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- December of 2006 ------------------------------ #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = BAA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BAA (ng/g):")

dev.off()
```

B.2.6.3 R Code For Figure 39

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
```

```
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.06; u2=0.12; u3=0.18; u4=0.24; u5=0.3

# ========================= April 2006 and April 2010 ========================= #
jpeg("wshrimp_googlemap_BaP_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = BaP # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# --------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = BaP # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
```

```
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BaP (ng/g):")

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_BaP_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )
```

```
# ---------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )
```

```
# --------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = BaP # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )
```

```
legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BaP (ng/g):")

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# =================== September 2005, July and September 2006 ================ #
jpeg("wshrimp_googlemap_BaP_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
```

```
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# ---------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
bg="white", title="BaP (ng/g):")

text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_BaP_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- October of 2005
```

```
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
```

```
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7), pt.cex=1.5,
bg="white", title="BaP (ng/g):")

dev.off()


# ==================== November 2005 and November 2006 ================ #
jpeg("wshrimp_googlemap_BaP_nov.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
```

```
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BaP (ng/g):")

dev.off()


# ==================== December 2005 and December 2006 =============== #
jpeg("wshrimp_googlemap_BaP_dec.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
```

```
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- December of 2006 ------------------------------- #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = BaP # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
```

```
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="BaP (ng/g):")
```

```
dev.off()
```

B.2.6.4 R Code For Figure 40

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.06; u2=0.12; u3=0.18; u4=0.24; u5=0.3

# ======================== April 2006 and April 2010 ======================== #
jpeg("wshrimp_googlemap_CHR_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = CHR # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()
```

```
for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# ---------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = CHR # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()
```

```
for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="CHR (ng/g):")

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```

```
# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_CHR_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
```

```
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# --------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = CHR # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
```

```
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="CHR (ng/g):")

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ================== September 2005, July and September 2006 =============== #
jpeg("wshrimp_googlemap_CHR_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
```

```
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
```

```
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# ---------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
```

```
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
```

```
bg="white", title="CHR (ng/g):")

text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_CHR_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- October of 2005
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}
```

```
# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7), pt.cex=1.5,
bg="white", title="CHR (ng/g):")

dev.off()


# ==================== November 2005 and November 2006 =============== #
jpeg("wshrimp_googlemap_CHR_nov.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
```

```
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()
```

```
for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="CHR (ng/g):")

dev.off()


# ==================== December 2005 and December 2006 =============== #
```

```
jpeg("wshrimp_googlemap_CHR_dec.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
```

```
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- December of 2006 ------------------------------ #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = CHR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
```

```
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="CHR (ng/g):")

dev.off()
```

B.2.6.5 R Code For Figure 41

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.06; u2=0.12; u3=0.18; u4=0.24; u5=0.3

# ========================= April 2006 and April 2010 ========================= #
jpeg("wshrimp_googlemap_FLA_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)
```

```
# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = FLA # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
```

```
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# ---------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = FLA # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
```

```
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLA (ng/g):" )

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_FLA_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# ---------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = FLA # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
```

```
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLA (ng/g):" )

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```

```
# ================== September 2005, July and September 2006 ================ #
jpeg("wshrimp_googlemap_FLA_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
```

```
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
```

```
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# --------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
```

```
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
bg="white", title="FLA (ng/g):" )

text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_FLA_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- October of 2005
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7), pt.cex=1.5,
bg="white", title="FLA (ng/g):" )

dev.off()


# ==================== November 2005 and November 2006 =============== #
jpeg("wshrimp_googlemap_FLA_nov.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
```

```
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
```

```
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
```

```
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLA (ng/g):")

dev.off()


# ===================== December 2005 and December 2006 ================ #
jpeg("wshrimp_googlemap_FLA_dec.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- December of 2006 ------------------------------- #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = FLA # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
```

```
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.06","0.06 ~ 0.12","0.12 ~ 0.18", "0.18 ~ 0.24",
"0.24 ~ 0.3", " > 0.3","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLA (ng/g):" )

dev.off()
```

B.2.6.6 R Code For Figure 42

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
```

```
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.2; u2=0.4; u3=0.6; u4=0.8; u5=1.0

# ======================== April 2006 and April 2010 ======================== #
jpeg("wshrimp_googlemap_FLU_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = FLU # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# --------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = FLU # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
```

```
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLU (ng/g):")

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_FLU_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )
```

```
# ---------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )
```

```
# ---------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = FLU # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
```

```
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLU (ng/g):" )

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ================== September 2005, July and September 2006 ================ #
jpeg("wshrimp_googlemap_FLU_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
```

```
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# --------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
bg="white", title="FLU (ng/g):" )

text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_FLU_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )
```

```
# ---------------------------- October of 2005
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )
```

```
legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7), pt.cex=1.5,
bg="white", title="FLU (ng/g):")

dev.off()


# ==================== November 2005 and November 2006 ================ #
jpeg("wshrimp_googlemap_FLU_nov.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
```

```
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLU (ng/g):" )

dev.off()


# ==================== December 2005 and December 2006 =============== #
jpeg("wshrimp_googlemap_FLU_dec.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
```

```
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- December of 2006 ------------------------------ #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = FLU # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
```

```
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.2","0.2 ~ 0.4","0.4 ~ 0.6", "0.6 ~ 0.8",
"0.8 ~ 1.0", " > 1.0","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="FLU (ng/g):")
```

```
dev.off()
```

B.2.6.7 R Code For Figure 7

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)


source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",  # for normal map c(-91.0,-89,-87.5)
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.5; u2=1.0; u3=1.5; u4=2.0; u5=2.5

# ======================== April 2006 and April 2010 ======================== #
jpeg("wshrimp_googlemap_NPH_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = NPH # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
```

```
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# --------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = NPH # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
```

```
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.5","0.5 ~ 1.0","1.0 ~ 1.5", "1.5 ~ 2.0",
"2.0 ~ 2.5", " > 2.5","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="NPH (ng/g):" )

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )
```

```
dev.off()


# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_NPH_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = NPH # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
```

```
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# ---------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = NPH # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
```

```
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )



legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.5","0.5 ~ 1.0","1.0 ~ 1.5", "1.5 ~ 2.0",
"2.0 ~ 2.5", " > 2.5","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="NPH (ng/g):" )

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ================== September 2005, July and September 2006 ================ #
jpeg("wshrimp_googlemap_NPH_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = NPH # !!!
```

```
l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = NPH # !!!
```

```
l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# --------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
```

```
toxicity = NPH # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.5","0.5 ~ 1.0","1.0 ~ 1.5", "1.5 ~ 2.0",
```

```
"2.0 ~ 2.5", " > 2.5","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
bg="white", title="NPH (ng/g):")

text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_NPH_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- October of 2005
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = NPH # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
```

```
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.5","0.5 ~ 1.0","1.0 ~ 1.5", "1.5 ~ 2.0",
"2.0 ~ 2.5", " > 2.5","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7),pt.cex=1.5,
bg="white", title="NPH (ng/g):")

dev.off()


# ==================== November 2005 and November 2006 =============== #
jpeg("wshrimp_googlemap_NPH_nov.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = NPH # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
```

```
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = NPH # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
```

```
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.5","0.5 ~ 1.0","1.0 ~ 1.5", "1.5 ~ 2.0",
"2.0 ~ 2.5", " > 2.5","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7),pt.cex=1.5,
bg="white", title="NPH (ng/g):")

dev.off()
```

```
# ==================== December 2005 and December 2006 =============== #
jpeg("wshrimp_googlemap_NPH_dec.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = NPH # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
```

```
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- December of 2006 ------------------------------ #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = NPH # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
```

```
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.5","0.5 ~ 1.0","1.0 ~ 1.5", "1.5 ~ 2.0",
"2.0 ~ 2.5", " > 2.5","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7),pt.cex=1.5,
bg="white", title="NPH (ng/g):" )

dev.off()
```

B.2.6.8 R Code For Figure 43

```
rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
bb <- qbbox(c(28,29,30), c(-91.0,-89,-88), TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

# BOUNDS
u1=0.1; u2=0.2; u3=0.3; u4=0.4; u5=0.5

# ======================== April 2006 and April 2010 ======================== #
jpeg("wshrimp_googlemap_PYR_april.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for April 30
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100430_1159\\area_20100430_1159.shp'
```

```
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- April of 2006
source("fish-baseline.R")
data = w.shrimp.april.2006  # !!!
toxicity = PYR # !!!PH

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
```

```
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# ---------------------------- April of 2010
source("fish-june2010.R")
data = w.shrimp.april.2010  # !!!
toxicity = PYR # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
```

```
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.1","0.1 ~ 0.2","0.2 ~ 0.3", "0.3 ~ 0.4",
"0.4 ~ 0.5", " > 0.5","April 2006","April 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="PYR (ng/g):")

text( 200, -225, "Oil spill area \n for April 30, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()



# ======================== May 2006 and May 2010 ======================== #
jpeg("wshrimp_googlemap_PYR_may.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 8
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100508_2351\\20100508_2351_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray45", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- May of 2006
source("fish-baseline.R")
data = w.shrimp.may.2006    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()
```

```
for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )


# --------------------------- May of 2010
source("fish-june2010.R")
data = w.shrimp.may.2010  # !!!
toxicity = PYR # !!!

l1_u1.10 = c()
l2_u2.10 = c()
l3_u3.10 = c()
l4_u4.10 = c()
l5_u5.10 = c()
gt_u6.10 = c()
```

```
for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.10 = rbind( l1_u1.10, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.10 = rbind( l2_u2.10, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.10 = rbind( l3_u3.10, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.10 = rbind( l4_u4.10, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.10 = rbind( l5_u5.10, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.10 = rbind( gt_u6.10, data[i,] )
}
}

# ------- Display locations
MyMap8 = PlotOnStaticMap( MyMap7, l1_u1.10[,7], l1_u1.10[,8], FUN = points,
lwd=2, pch=21, cex=1.5, col = "yellow", add = T )
MyMap9 = PlotOnStaticMap( MyMap8, l2_u2.10[,7], l2_u2.10[,8], FUN = points,
lwd=2, pch=22, cex=1.5, col = "yellow", add = T )
MyMap10 = PlotOnStaticMap( MyMap9, l3_u3.10[,7], l3_u3.10[,8], FUN = points,
lwd=2, pch=23, cex=1.5, col = "yellow", add = T )
MyMap11 = PlotOnStaticMap( MyMap10, l4_u4.10[,7], l4_u4.10[,8], FUN = points,
lwd=2, pch=24, cex=1.5, col = "yellow", add = T )
MyMap12 = PlotOnStaticMap( MyMap11, l5_u5.10[,7], l5_u5.10[,8], FUN = points,
lwd=2, pch=25, cex=1.5, col = "yellow", add = T )
MyMap13 = PlotOnStaticMap( MyMap12, gt_u6.10[,7], gt_u6.10[,8], FUN = points,
lwd=2, pch=14, cex=1.5, col = "yellow", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.1","0.1 ~ 0.2","0.2 ~ 0.3", "0.3 ~ 0.4",
"0.4 ~ 0.5", " > 0.5","May 2006","May 2010","Oil Wellhead"),
col = c("black","black","black","black","black","black","red","yellow","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="PYR (ng/g):")

text( 200, -225, "Oil spill area \n for May 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```

```
# ================== September 2005, July and September 2006 ================ #
jpeg("wshrimp_googlemap_PYR_JulySep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# --------------------------- September of 2005
source("fish-baseline.R")
data = w.shrimp.sep.2005    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
```

```
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# ---------------------------- July of 2006
source("fish-baseline.R")
data = w.shrimp.july.2006    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
```

```
FUN = points, lwd=2, pch=21, cex=1.5, col = "magenta", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "magenta", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "magenta", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "magenta", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "magenta", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "magenta", add = T )


# ---------------------------- September of 2006
source("fish-baseline.R")
data = w.shrimp.sep.2006    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
```

```
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.28,
legend = c("0 ~ 0.1","0.1 ~ 0.2","0.2 ~ 0.3", "0.3 ~ 0.4",
"0.4 ~ 0.5", " > 0.5","September 2005","July 2006","September 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","magenta","red","black"),
pch=c(21,22,23,24,25,14,16,16,16,7), pt.cex=1.5,
bg="white", title="PYR (ng/g):")

text( 50, -250, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ======================== October 2005 ======================== #
jpeg("wshrimp_googlemap_PYR_oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- October of 2005
source("fish-baseline.R")
data = w.shrimp.oct.2005    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
```

```
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.38,
legend = c("0 ~ 0.1","0.1 ~ 0.2","0.2 ~ 0.3", "0.3 ~ 0.4",
"0.4 ~ 0.5", " > 0.5","October 2005","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","black"),
pch=c(21,22,23,24,25,14,16,7), pt.cex=1.5,
bg="white", title="PYR (ng/g):")

dev.off()


# ==================== November 2005 and November 2006 =============== #
jpeg("wshrimp_googlemap_PYR_nov.jpg", width=7.5, height=7.5, units="in", res=90)
```

```
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# -------------------------- November of 2005
source("fish-baseline.R")
data = w.shrimp.nov.2005    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
```

```
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- November of 2006
source("fish-baseline.R")
data = w.shrimp.nov.2006    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
```

```
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.1","0.1 ~ 0.2","0.2 ~ 0.3", "0.3 ~ 0.4",
"0.4 ~ 0.5", " > 0.5","November 2005","November 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="PYR (ng/g):")

dev.off()


# ==================== December 2005 and December 2006 ================ #
jpeg("wshrimp_googlemap_PYR_dec.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# ---------------------------- December of 2005
source("fish-baseline.R")
data = w.shrimp.dec.2005    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
```

```
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "navy", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "navy", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "navy", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "navy", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "navy", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "navy", add = T )


# --------------------------- December of 2006 ------------------------------ #
source("fish-baseline.R")
data = w.shrimp.dec.2006    # !!!
toxicity = PYR # !!!

l1_u1.0506 = c()
l2_u2.0506 = c()
l3_u3.0506 = c()
l4_u4.0506 = c()
l5_u5.0506 = c()
gt_u6.0506 = c()

for( i in 1:length(data[,1]) ){
if( data[i,toxicity] < u1 ){
l1_u1.0506 = rbind( l1_u1.0506, data[i,] )
}
if( data[i,toxicity] >= u1 & data[i,toxicity] < u2 ){
l2_u2.0506 = rbind( l2_u2.0506, data[i,] )
}
if( data[i,toxicity] >= u2 & data[i,toxicity] < u3 ){
```

```
l3_u3.0506 = rbind( l3_u3.0506, data[i,] )
}
if( data[i,toxicity] >= u3 & data[i,toxicity] < u4 ){
l4_u4.0506 = rbind( l4_u4.0506, data[i,] )
}
if( data[i,toxicity] >= u4 & data[i,toxicity] < u5 ){
l5_u5.0506 = rbind( l5_u5.0506, data[i,] )
}
if( data[i,toxicity] >= u5 ){
gt_u6.0506 = rbind( gt_u6.0506, data[i,] )
}
}

# ------- Display locations
MyMap2 = PlotOnStaticMap( MyMap, l1_u1.0506[,5], l1_u1.0506[,6],
FUN = points, lwd=2, pch=21, cex=1.5, col = "red", add = T )
MyMap3 = PlotOnStaticMap( MyMap2, l2_u2.0506[,5], l2_u2.0506[,6],
FUN = points, lwd=2, pch=22, cex=1.5, col = "red", add = T )
MyMap4 = PlotOnStaticMap( MyMap3, l3_u3.0506[,5], l3_u3.0506[,6],
FUN = points, lwd=2, pch=23, cex=1.5, col = "red", add = T )
MyMap5 = PlotOnStaticMap( MyMap4, l4_u4.0506[,5], l4_u4.0506[,6],
FUN = points, lwd=2, pch=24, cex=1.5, col = "red", add = T )
MyMap6 = PlotOnStaticMap( MyMap5, l5_u5.0506[,5], l5_u5.0506[,6],
FUN = points, lwd=2, pch=25, cex=1.5, col = "red", add = T )
MyMap7 = PlotOnStaticMap( MyMap6, gt_u6.0506[,5], gt_u6.0506[,6],
FUN = points, lwd=2, pch=14, cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.33,
legend = c("0 ~ 0.1","0.1 ~ 0.2","0.2 ~ 0.3", "0.3 ~ 0.4",
"0.4 ~ 0.5", " > 0.5","December 2005","December 2006","Oil Wellhead"),
col = c("black","black","black","black","black","black","navy","red","black"),
pch=c(21,22,23,24,25,14,16,16,7), pt.cex=1.5,
bg="white", title="PYR (ng/g):")

dev.off()
```

B.2.7 R Code for Figure 8

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/4_FISH")

rm(list=ls())

# ------------------ White Shrimps for 2010 ----------------------------- #
```

```
source("fish-june2010.R")

w.shrimp.2010 = cbind( w.shrimp[,9:17], rep("2010", length(w.shrimp[,1])) )
colnames(w.shrimp.2010) <- c( "Date","NPH","FLU","ANT.PHN","FLA","PYR","BAA",
"CHR","BaP", "Year" )


source("fish-baseline.R")
# ------------------- White Shrimps for 2005 ------------------------------ #
w.shrimp.2005 = white.2005[,c(4, 7:14)]
# reorder toxicity columns like 2010's
w.shrimp.2005 = cbind( w.shrimp.2005[,1:5], w.shrimp.2005[,9],
w.shrimp.2005[,8], w.shrimp.2005[,6:7], rep("2005", length(w.shrimp.2005[,1])) )
colnames(w.shrimp.2005) <- c( "Date","NPH","FLU","ANT.PHN","FLA","PYR","BAA",
"CHR","BaP","Year")

# ------------------- White Shrimps for 2006 ------------------------------ #
# Delete the outliers:
for( i in 1:length( white.2006[,1] ) ){
if( white.2006$PYR[i] == 2.8 ){ # 1 outlier
white.2006$PYR[i] = NA
}
if( white.2006$BaP[i] == 0.530 ){ # 1 outlier
white.2006$BaP[i] = NA
}
if( white.2006$CHR[i] >= 0.66 ){ # 3 outliers
white.2006$CHR[i] = NA
}
}

w.shrimp.2006 = white.2006[,c(4, 7:14)]
# reorder toxicity columns like 2010's
w.shrimp.2006 = cbind( w.shrimp.2006[,1:5], w.shrimp.2006[,9],
w.shrimp.2006[,8], w.shrimp.2006[,6:7], rep("2006", length(w.shrimp.2006[,1])) )
colnames(w.shrimp.2006) <- c( "Date","NPH","FLU","ANT.PHN","FLA","PYR","BAA",
"CHR","BaP","Year" )

#### Combine all data
w.shrimp = rbind( w.shrimp.2005, w.shrimp.2006, w.shrimp.2010 )

#=====================================
library(car)

pdf(file = "ScatterplotMatrix.pdf",width=10,height=10,pointsize = 12,bg = "white")
scatterplotMatrix( ~ NPH + FLU + ANT.PHN + FLA + PYR + BAA + CHR + BaP | Year,
data = w.shrimp, diagonal="none", smooth = FALSE, reg.line=FALSE,
col = c("black", "red", "blue"),
```

```
cex.main = 1.75, main = "PAHs components in white shrimps" )
dev.off()
```

B.3 R Code for Bird

B.3.1 R Code for Reading Bird Data

```
# Save R code below in your folder as a "BirdDataReading.R".
# R code for other figures will refer to it through "source("BirdDataReading.R")"

#----------Reading Bird Data----------#
bird = read.csv(url("http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/birds.csv"),
sep=",", head = TRUE, as.is=TRUE)

# ------------------------Adding "Month" column----------------------- #
Month = bird$Date
Month = substr(Month,1,nchar(Month)-3)
Month[Month == "2010-05"] = "May"
Month[Month == "2010-06"] = "June"
Month[Month == "2010-07"] = "July"
Month[Month == "2010-08"] = "August"
Month[Month == "2010-09"] = "September"
Month[Month == "2010-10"] = "October"
bird = cbind(bird, Month)



################################################################################
# ================= Separating by Biological Order ========================= #
################################################################################
RedtailedHawk = c(); UniHawk = c(); CanadaGoose = c(); LesserScaup = c();
Mallard = c(); MottledDuck = c(); RedBreastedMerganser = c();
RudyDuck = c(); SurfScoter = c(); UniDuck = c(); CommonNighthawk = c();
AmericanOystercatcher = c(); BlackOystercatcher = c(); BlackSkimmer = c();
BlackTern = c(); BlackneckedStilt = c(); BluewingedTeal = c(); CaspianTern = c();
CommonTern = c(); ForstersTern = c(); GullbilledTern = c(); HerringGull = c();
Killdeer = c(); LaughingGull = c(); LeastTern = c(); LesserBlackbackedGull = c();
LongBilledDowitcher = c(); PipingPlover = c(); RingbilledGull = c();
RoyalTern = c(); RuddyTurnstone = c(); Sanderling = c(); SandwichTern = c();
SemipalmatedSandpiper = c(); ShortbilledDowitcher = c(); SootyTern = c();
SpottedSandpiper = c(); UniDowitcher = c(); UniGull = c();
UniSandpiper = c(); UniShorebird = c(); UniSkimmer = c();
UniTern = c(); Willet = c(); WilsonsPlover = c(); BlackCrownedNightHeron = c();
```

```
CattleEgret = c(); GlossyIbis = c();
GreatBlueHeron = c(); GreatEgret = c(); GreatHornedOwl = c(); GreenHeron = c();
LeastBittern = c(); LittleBlueHeron = c(); ReddishEgret = c(); RoseateSpoonbill = c();
SnowyEgret = c(); TricoloredHeron = c(); UniHeron = c(); WhiteIbis = c();
YellowcrownedNightHeron = c(); EurasianCollaredDove = c(); MourningDove = c();
RockPigeon = c(); UniPigeon = c(); WhitewingedDove = c();
BeltedKingFisher = c(); YellowbilledCuckoo = c(); Osprey = c(); CommonLoon = c();
CommonMoorhen = c(); UniLoon = c(); AmericanCoot = c(); ClapperRail = c();
PurpleGallinule = c(); Sora = c(); UniRail = c(); VirginiaRail = c();
Other = c(); AmericanRedstart = c(); BarnSwallow = c(); BoattailedGrackle = c();
CommonYellowthroat = c(); EasternKingbird = c(); EasternMeadowlark = c();
HouseSparrow = c(); NorthernCardinal = c(); NorthernMockingbird = c();
PurpleMartin = c(); RedwingedBlackbird = c(); SeasideSparrow = c();
UniBlackbird = c(); UniFlycatcher = c(); UniGrackle = c();
UniMockingbird = c(); UniSparrow = c(); UniSwallow = c();
AmericanWhitePelican = c(); BrownPelican = c(); DoublecrestedCormorant = c();
MagnificentFrigatebird = c(); MaskedBooby = c(); NeotropicCormorant = c();
NorthernGannet = c(); UniCormorant = c(); UniEgret = c();
UniPelican = c(); HornedGrebe = c(); PiedbillGrebe = c();
UniGrebe = c(); AudubonsShearwater = c(); GreaterShearwater = c();
ManxShearwater = c(); UniShearwater = c(); WilsonsStormpetrel = c();
BarnOwl = c(); UniOwl = c(); Unknown = c(); UniRaptor = c();


for( i in 1:length(bird[,1]) ){
if( substr( bird[i,1], 1, 15 ) == "Red-tailed Hawk" ){RedtailedHawk = rbind( RedtailedHawk, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Unidentified Hawk" ){UniHawk = rbind( UniHawk, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Canada Goose" ){CanadaGoose = rbind( CanadaGoose, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Lesser Scaup" ){LesserScaup = rbind( LesserScaup, bird[i,] )}
if( substr( bird[i,1], 1, 7 ) == "Mallard" ){Mallard = rbind( Mallard, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Mottled Duck" ){MottledDuck = rbind( MottledDuck, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Red-Breasted Merganser" ){
RedBreastedMerganser = rbind( RedBreastedMerganser, bird[i,] )}
if( substr( bird[i,1], 1, 9 ) == "Rudy Duck" ){RudyDuck = rbind( RudyDuck, bird[i,] )}
if( substr( bird[i,1], 1, 11 ) == "Surf Scoter" ){SurfScoter = rbind( SurfScoter, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Unidentified Duck" ){UniDuck = rbind( UniDuck, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Common Nighthawk" ){CommonNighthawk = rbind( CommonNighthawk, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "American Oystercatcher" ){
AmericanOystercatcher = rbind( AmericanOystercatcher, bird[i,] )}
if( substr( bird[i,1], 1, 19 ) == "Black Oystercatcher" ){
BlackOystercatcher = rbind( BlackOystercatcher, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Black Skimmer" ){BlackSkimmer = rbind( BlackSkimmer, bird[i,] )}
if( substr( bird[i,1], 1, 10 ) == "Black Tern" ){BlackTern = rbind( BlackTern, bird[i,] )}
if( substr( bird[i,1], 1, 18 ) == "Black-necked Stilt" ){
BlackneckedStilt = rbind( BlackneckedStilt, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Blue-winged Teal" ){BluewingedTeal = rbind( BluewingedTeal, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Caspian Tern" ){CaspianTern = rbind( CaspianTern, bird[i,] )}
```

```
if( substr( bird[i,1], 1, 11 ) == "Common Tern" ){CommonTern = rbind( CommonTern, bird[i,] )}
if( substr( bird[i,1], 1, 14 ) == "Forster's Tern" ){ForstersTern = rbind( ForstersTern, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Gull-billed Tern" ){GullbilledTern = rbind( GullbilledTern, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Herring Gull" ){HerringGull = rbind( HerringGull, bird[i,] )}
if( substr( bird[i,1], 1, 8 ) == "Killdeer" ){Killdeer = rbind( Killdeer, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Laughing Gull" ){LaughingGull = rbind( LaughingGull, bird[i,] )}
if( substr( bird[i,1], 1, 10 ) == "Least Tern" ){LeastTern = rbind( LeastTern, bird[i,] )}
if( substr( bird[i,1], 1, 24 ) == "Lesser Black-backed Gull" ){
LesserBlackbackedGull = rbind( LesserBlackbackedGull, bird[i,] )}
if( substr( bird[i,1], 1, 21 ) == "Long-Billed Dowitcher" ){
LongBilledDowitcher = rbind( LongBilledDowitcher, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Piping Plover" ){PipingPlover = rbind( PipingPlover, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Ring-billed Gull" ){RingbilledGull = rbind( RingbilledGull, bird[i,] )}
if( substr( bird[i,1], 1, 10 ) == "Royal Tern" ){RoyalTern = rbind( RoyalTern, bird[i,] )}
if( substr( bird[i,1], 1, 15 ) == "Ruddy Turnstone" ){RuddyTurnstone = rbind( RuddyTurnstone, bird[i,] )}
if( substr( bird[i,1], 1, 10 ) == "Sanderling" ){Sanderling = rbind( Sanderling, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Sandwich Tern" ){SandwichTern = rbind( SandwichTern, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Semipalmated Sandpiper" ){
SemipalmatedSandpiper = rbind( SemipalmatedSandpiper, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Short-billed Dowitcher" ){
ShortbilledDowitcher = rbind( ShortbilledDowitcher, bird[i,] )}
if( substr( bird[i,1], 1, 10 ) == "Sooty Tern" ){SootyTern = rbind( SootyTern, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Spotted Sandpiper" ){
SpottedSandpiper = rbind( SpottedSandpiper, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Unidentified Dowitcher" ){UniDowitcher = rbind( UniDowitcher, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Unidentified Gull" ){UniGull = rbind( UniGull, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Unidentified Sandpiper" ){UniSandpiper = rbind( UniSandpiper, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Unidentified Shorebird" ){UniShorebird = rbind( UniShorebird, bird[i,] )}
if( substr( bird[i,1], 1, 20 ) == "Unidentified Skimmer" ){UniSkimmer = rbind( UniSkimmer, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Unidentified Tern" ){UniTern = rbind( UniTern, bird[i,] )}
if( substr( bird[i,1], 1, 6 ) == "Willet" ){Willet = rbind( Willet, bird[i,] )}
if( substr( bird[i,1], 1, 15 ) == "Wilson's Plover" ){WilsonsPlover = rbind( WilsonsPlover, bird[i,] )}
if( substr( bird[i,1], 1, 25 ) == "Black Crowned Night Heron" ){
BlackCrownedNightHeron = rbind( BlackCrownedNightHeron, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Cattle Egret" ){CattleEgret = rbind( CattleEgret, bird[i,] )}
if( substr( bird[i,1], 1, 11 ) == "Glossy Ibis" ){GlossyIbis = rbind( GlossyIbis, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Great Blue Heron" ){GreatBlueHeron = rbind( GreatBlueHeron, bird[i,] )}
if( substr( bird[i,1], 1, 11 ) == "Great Egret" ){GreatEgret = rbind( GreatEgret, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Great Horned Owl" ){GreatHornedOwl = rbind( GreatHornedOwl, bird[i,] )}
if( substr( bird[i,1], 1, 11 ) == "Green Heron" ){GreenHeron = rbind( GreenHeron, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Least Bittern" ){LeastBittern = rbind( LeastBittern, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Little Blue Heron" ){LittleBlueHeron = rbind( LittleBlueHeron, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Reddish Egret" ){ReddishEgret = rbind( ReddishEgret, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Roseate Spoonbill" ){
RoseateSpoonbill = rbind( RoseateSpoonbill, bird[i,] )}
if( substr( bird[i,1], 1, 11 ) == "Snowy Egret" ){SnowyEgret = rbind( SnowyEgret, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Tricolored Heron" ){TricoloredHeron = rbind( TricoloredHeron, bird[i,] )}
```

```
if( substr( bird[i,1], 1, 18 ) == "Unidentified Heron" ){UniHeron = rbind( UniHeron, bird[i,] )}
if( substr( bird[i,1], 1, 10 ) == "White Ibis" ){WhiteIbis = rbind( WhiteIbis, bird[i,] )}
if( substr( bird[i,1], 1, 26 ) == "Yellow-crowned Night-Heron" ){
YellowcrownedNightHeron = rbind( YellowcrownedNightHeron, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Eurasian Collared-Dove" ){
EurasianCollaredDove = rbind( EurasianCollaredDove, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Mourning Dove" ){MourningDove = rbind( MourningDove, bird[i,] )}
if( substr( bird[i,1], 1, 11 ) == "Rock Pigeon" ){RockPigeon = rbind( RockPigeon, bird[i,] )}
if( substr( bird[i,1], 1, 19 ) == "Unidentified Pigeon" ){UniPigeon = rbind( UniPigeon, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "White-winged Dove" ){WhitewingedDove = rbind( WhitewingedDove, bird[i,] )}
if( substr( bird[i,1], 1, 18 ) == "Belted King Fisher" ){
BeltedKingFisher = rbind( BeltedKingFisher, bird[i,] )}
if( substr( bird[i,1], 1, 20 ) == "Yellow-billed Cuckoo" ){
YellowbilledCuckoo = rbind( YellowbilledCuckoo, bird[i,] )}
if( substr( bird[i,1], 1, 6 ) == "Osprey" ){Osprey = rbind( Osprey, bird[i,] )}
if( substr( bird[i,1], 1, 11 ) == "Common Loon" ){CommonLoon = rbind( CommonLoon, bird[i,] )}
if( substr( bird[i,1], 1, 14 ) == "Common Moorhen" ){CommonMoorhen = rbind( CommonMoorhen, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Unidentified Loon" ){UniLoon = rbind( UniLoon, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "American Coot" ){AmericanCoot = rbind( AmericanCoot, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Clapper Rail" ){ClapperRail = rbind( ClapperRail, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Purple Gallinule" ){PurpleGallinule = rbind( PurpleGallinule, bird[i,] )}
if( substr( bird[i,1], 1, 4 ) == "Sora" ){Sora = rbind( Sora, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Unidentified Rail" ){UniRail = rbind( UniRail, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Virginia Rail" ){VirginiaRail = rbind( VirginiaRail, bird[i,] )}
if( substr( bird[i,1], 1, 5 ) == "Other" ){Other = rbind( Other, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "American Redstart" ){
AmericanRedstart = rbind( AmericanRedstart, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Barn Swallow" ){
BarnSwallow = rbind( BarnSwallow, bird[i,] )}
if( substr( bird[i,1], 1, 19 ) == "Boat-tailed Grackle" ){
BoattailedGrackle = rbind( BoattailedGrackle, bird[i,] )}
if( substr( bird[i,1], 1, 19 ) == "Common Yellowthroat" ){
CommonYellowthroat = rbind( CommonYellowthroat, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Eastern Kingbird" ){EasternKingbird = rbind( EasternKingbird, bird[i,] )}
if( substr( bird[i,1], 1, 18 ) == "Eastern Meadowlark" ){
EasternMeadowlark = rbind( EasternMeadowlark, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "House Sparrow" ){HouseSparrow = rbind( HouseSparrow, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Northern Cardinal" ){
NorthernCardinal = rbind( NorthernCardinal, bird[i,] )}
if( substr( bird[i,1], 1, 20 ) == "Northern Mockingbird" ){
NorthernMockingbird = rbind( NorthernMockingbird, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Purple Martin" ){PurpleMartin = rbind( PurpleMartin, bird[i,] )}
if( substr( bird[i,1], 1, 17 ) == "Red-winged Blackbird" ){
RedwingedBlackbird = rbind( RedwingedBlackbird, bird[i,] )}
if( substr( bird[i,1], 1, 15 ) == "Seaside Sparrow" ){SeasideSparrow = rbind( SeasideSparrow, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Unidentified Blackbird" ){UniBlackbird = rbind( UniBlackbird, bird[i,] )}
if( substr( bird[i,1], 1, 23 ) == "Unidentified Flycatcher" ){
```

```
UniFlycatcher = rbind( UniFlycatcher, bird[i,] )}
if( substr( bird[i,1], 1, 20 ) == "Unidentified Grackle" ){UniGrackle = rbind( UniGrackle, bird[i,] )}
if( substr( bird[i,1], 1, 24 ) == "Unidentified Mockingbird" ){
UniMockingbird = rbind( UniMockingbird, bird[i,] )}
if( substr( bird[i,1], 1, 21 ) == "Unidentified Sparrow" ){UniSparrow = rbind( UniSparrow, bird[i,] )}
if( substr( bird[i,1], 1, 20 ) == "Unidentified Swallow" ){UniSwallow = rbind( UniSwallow, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "American White Pelican" ){
AmericanWhitePelican = rbind( AmericanWhitePelican, bird[i,] )}
if( substr( bird[i,1], 1, 13 ) == "Brown Pelican" ){BrownPelican = rbind( BrownPelican, bird[i,] )}
if( substr( bird[i,1], 1, 24 ) == "Double-crested Cormorant" ){
DoublecrestedCormorant = rbind( DoublecrestedCormorant, bird[i,] )}
if( substr( bird[i,1], 1, 23 ) == "Magnificent Frigatebird" ){
MagnificentFrigatebird = rbind( MagnificentFrigatebird, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Masked Booby" ){MaskedBooby = rbind( MaskedBooby, bird[i,] )}
if( substr( bird[i,1], 1, 19 ) == "Neotropic Cormorant" ){
NeotropicCormorant = rbind( NeotropicCormorant, bird[i,] )}
if( substr( bird[i,1], 1, 15 ) == "Northern Gannet" ){NorthernGannet = rbind( NorthernGannet, bird[i,] )}
if( substr( bird[i,1], 1, 22 ) == "Unidentified Cormorant" ){UniCormorant = rbind( UniCormorant, bird[i,] )}
if( substr( bird[i,1], 1, 18 ) == "Unidentified Egret" ){UniEgret = rbind( UniEgret, bird[i,] )}
if( substr( bird[i,1], 1, 20 ) == "Unidentified Pelican" ){UniPelican = rbind( UniPelican, bird[i,] )}
if( substr( bird[i,1], 1, 12 ) == "Horned Grebe" ){HornedGrebe = rbind( HornedGrebe, bird[i,] )}
if( substr( bird[i,1], 1, 15 ) == "Pied-bill Grebe" ){PiedbillGrebe = rbind( PiedbillGrebe, bird[i,] )}
if( substr( bird[i,1], 1, 18 ) == "Unidentified Grebe" ){UniGrebe = rbind( UniGrebe, bird[i,] )}
if( substr( bird[i,1], 1, 20 ) == "Audubon's Shearwater" ){
AudubonsShearwater = rbind( AudubonsShearwater, bird[i,] )}
if( substr( bird[i,1], 1, 18 ) == "Greater Shearwater" ){
GreaterShearwater = rbind( GreaterShearwater, bird[i,] )}
if( substr( bird[i,1], 1, 15 ) == "Manx Shearwater" ){ManxShearwater = rbind( ManxShearwater, bird[i,] )}
if( substr( bird[i,1], 1, 23 ) == "Unidentified Shearwater" ){
UniShearwater = rbind( UniShearwater, bird[i,] )}
if( substr( bird[i,1], 1, 21 ) == "Wilson's Storm-petrel" ){
WilsonsStormpetrel = rbind( WilsonsStormpetrel, bird[i,] )}
if( substr( bird[i,1], 1, 8 ) == "Barn Owl" ){BarnOwl = rbind( BarnOwl, bird[i,] )}
if( substr( bird[i,1], 1, 16 ) == "Unidentified Owl" ){UniOwl = rbind( UniOwl, bird[i,] )}
if( substr( bird[i,1], 1, 7 ) == "Unknown" ){Unknown = rbind( Unknown, bird[i,] )}
if( substr( bird[i,1], 1, 19 ) == "Unidentified Raptor" ){UniRaptor = rbind( UniRaptor, bird[i,] )}
}

Accipitriformes = rbind( RedtailedHawk, UniHawk )
Anseriformes = rbind( CanadaGoose, LesserScaup, Mallard, MottledDuck,
RedBreastedMerganser, RudyDuck, SurfScoter, UniDuck )
Caprimulgiformes = CommonNighthawk
Charadriiformes = rbind( AmericanOystercatcher, BlackOystercatcher, BlackSkimmer,
BlackTern, BlackneckedStilt, BluewingedTeal, CaspianTern, CommonTern,
ForstersTern, GullbilledTern, HerringGull, Killdeer, LaughingGull, LeastTern,
LesserBlackbackedGull, LongBilledDowitcher, PipingPlover, RingbilledGull,
RoyalTern, RuddyTurnstone, Sanderling, SandwichTern, SemipalmatedSandpiper,
```

```
ShortbilledDowitcher, SootyTern, SpottedSandpiper, UniDowitcher, UniGull,
UniSandpiper, UniShorebird, UniSkimmer, UniTern, Willet, WilsonsPlover )
Ciconiiformes = rbind( BlackCrownedNightHeron, CattleEgret, GlossyIbis,
GreatBlueHeron, GreatEgret, GreatHornedOwl, GreenHeron, LeastBittern,
LittleBlueHeron, ReddishEgret, RoseateSpoonbill, SnowyEgret,
TricoloredHeron, UniHeron, WhiteIbis, YellowcrownedNightHeron )
Columbiformes = rbind( EurasianCollaredDove, MourningDove, RockPigeon, UniPigeon,
WhitewingedDove )
Coraciiformes = BeltedKingFisher
Cuculiformes = YellowbilledCuckoo
Falconiformes = Osprey
Gaviiformes = rbind( CommonLoon, CommonMoorhen, UniLoon )
Gruiformes = rbind( AmericanCoot, ClapperRail, PurpleGallinule, Sora, UniRail,
VirginiaRail )
Passeriformes = rbind( AmericanRedstart, BarnSwallow, BoattailedGrackle,
CommonYellowthroat, EasternKingbird, EasternMeadowlark, HouseSparrow,
NorthernCardinal, NorthernMockingbird, PurpleMartin, RedwingedBlackbird,
SeasideSparrow, UniBlackbird, UniFlycatcher, UniGrackle, UniMockingbird,
UniSparrow, UniSwallow )
Pelecaniformes = rbind( AmericanWhitePelican, BrownPelican, DoublecrestedCormorant,
MagnificentFrigatebird, MaskedBooby, NeotropicCormorant, NorthernGannet,
UniCormorant, UniEgret, UniPelican )
Podicipediformes = rbind( HornedGrebe, PiedbillGrebe, UniGrebe )
Procellariiformes = rbind( AudubonsShearwater, GreaterShearwater, ManxShearwater,
UniShearwater, WilsonsStormpetrel )
Stigiformes = rbind( BarnOwl, UniOwl )


# -----------------------Adding "Biological Order" column---------------------- #
Accipitriformes = cbind(Accipitriformes, rep("Accipitriformes", length(Accipitriformes[,1])))
colnames(Accipitriformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Anseriformes = cbind(Anseriformes, rep("Anseriformes", length(Anseriformes[,1])))
colnames(Anseriformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Caprimulgiformes = cbind(Caprimulgiformes, rep("Caprimulgiformes", length(Caprimulgiformes[,1])))
colnames(Caprimulgiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Charadriiformes = cbind(Charadriiformes, rep("Charadriiformes", length(Charadriiformes[,1])))
colnames(Charadriiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Ciconiiformes = cbind(Ciconiiformes, rep("Ciconiiformes", length(Ciconiiformes[,1])))
colnames(Ciconiiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
```

```
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Columbiformes = cbind(Columbiformes, rep("Columbiformes", length(Columbiformes[,1])))
colnames(Columbiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Coraciiformes = cbind(Coraciiformes, rep("Coraciiformes", length(Coraciiformes[,1])))
colnames(Coraciiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Cuculiformes = cbind(Cuculiformes, rep("Cuculiformes", length(Cuculiformes[,1])))
colnames(Cuculiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Falconiformes = cbind(Falconiformes, rep("Falconiformes", length(Falconiformes[,1])))
colnames(Falconiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Gaviiformes = cbind(Gaviiformes, rep("Gaviiformes", length(Gaviiformes[,1])))
colnames(Gaviiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Gruiformes = cbind(Gruiformes, rep("Gruiformes", length(Gruiformes[,1])))
colnames(Gruiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Passeriformes = cbind(Passeriformes, rep("Passeriformes", length(Passeriformes[,1])))
colnames(Passeriformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Pelecaniformes = cbind(Pelecaniformes, rep("Pelecaniformes", length(Pelecaniformes[,1])))
colnames(Pelecaniformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Podicipediformes = cbind(Podicipediformes, rep("Podicipediformes", length(Podicipediformes[,1])))
colnames(Podicipediformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Procellariiformes = cbind(Procellariiformes, rep("Procellariiformes", length(Procellariiformes[,1])))
colnames(Procellariiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Stigiformes = cbind(Stigiformes, rep("Stigiformes", length(Stigiformes[,1])))
colnames(Stigiformes) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Other = cbind(Other, rep("Other", length(Other[,1])))
```

```
colnames(Other) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

UniRaptor = cbind(UniRaptor, rep("Other", length(UniRaptor[,1])))
colnames(UniRaptor) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

Unknown = cbind(Unknown, rep("Unknown", length(Unknown[,1])))
colnames(Unknown) = c("Species", "Latitude", "Longitude", "Oiling", "Condition",
"BirdCount", "Date_", "Oil_Cond", "Date", "week.number", "Month", "BiologicalOrder")

bird = rbind(Accipitriformes, Anseriformes, Caprimulgiformes, Charadriiformes,
Ciconiiformes, Columbiformes, Coraciiformes, Cuculiformes, Falconiformes,
Gaviiformes, Gruiformes, Passeriformes, Pelecaniformes, Podicipediformes,
Procellariiformes, Stigiformes, Other, UniRaptor, Unknown)



# ============= Biological Order vs Dead/Live vs Week ======================== #
BiOrderCondWeek = function( Data = Unknown, Condition = "Dead", Week = "33" ){
y = c()
z = c()

for( j in 1:length(Data[,1]) ){
if( substr( Data[j,5], 1, nchar(Condition) ) == Condition ){
y = rbind( y, Data[j,] )
}
}

for( k in 1:length(y[,1]) ){
if( substr( y[k,10], 1, nchar(Week) ) == Week )  {
z = rbind( z, y[k,] )
}
}
z
}

#tt=BiOrderCondWeek( Data=Procellariiformes, Condition="Dead", Week = "33" )


# =================== Oiling vs Dead/Live ============================= #
OilingCond = function(Data=Procellariiformes, Oiling="Visibly Oiled", Condition="Dead"){
x = c()
y = c()

for( i in 1:length(Data[,1]) ){
if( substr( Data[i,4], 1, nchar(Oiling) ) == Oiling ){
```

```
x = rbind( x, Data[i,] )
}
}

for( j in 1:length(x[,1]) ){
if( substr( x[j,5], 1, nchar(Condition) ) == Condition ){
y = rbind( y, x[j,] )
}
}
y
}
# t=OilingCond( Data=Procellariiformes, Oiling = "Visibly Oiled", Condition="Live" )


# =================== Oiling vs Dead/Live vs Month ========================== #
OilingCondMonth = function( Data = Procellariiformes, Oiling = "Visibly Oiled",
Condition = "Dead", Month = "2010-08" ){
x = c()
y = c()
z = c()

for( i in 1:length(Data[,1]) ){
if( substr( Data[i,4], 1, nchar(Oiling) ) == Oiling ){
x = rbind( x, Data[i,] )
}
}

for( j in 1:length(x[,1]) ){
if( substr( x[j,5], 1, nchar(Condition) ) == Condition ){
y = rbind( y, x[j,] )
}
}

for( k in 1:length(y[,1]) ){
if( substr( y[k,7], 1, nchar(Month) ) == Month )  {
z = rbind( z, y[k,] )
}
}
z
}
# tt=OilingCondMonth( Data=Anseriformes, Oiling = "Visibly Oiled", Condition="Dead",
# Month = "2010-07" )


# =================== Oiling vs Dead/Live vs Week ========================== #
OilingCondWeek = function( Data = Procellariiformes, Oiling = "Visibly Oiled",
Condition = "Dead", Week = "33" ){
```

```
x = c()
y = c()
z = c()

for( i in 1:length(Data[,1]) ){
if( substr( Data[i,4], 1, nchar(Oiling) ) == Oiling ){
x = rbind( x, Data[i,] )
}
}

for( j in 1:length(x[,1]) ){
if( substr( x[j,5], 1, nchar(Condition) ) == Condition ){
y = rbind( y, x[j,] )
}
}

for( k in 1:length(y[,1]) ){
if( substr( y[k,10], 1, nchar(Week) ) == Week )  {
z = rbind( z, y[k,] )
}
}
z
}

#tt=OilingCondWeek( Data=Procellariiformes, Oiling = "Visibly Oiled", Condition="Dead",
# Week = "33" )
```

B.3.2 R Code for Figure 15

```
library(fields)

rm(list=ls())

source("BirdDataReading.R")

x = cbind(rep(19:40))
y = rbind( length(bird.live.19$Condition), length(bird.live.20$Condition),
length(bird.live.21$Condition), length(bird.live.22$Condition),
length(bird.live.23$Condition), length(bird.live.24$Condition),
length(bird.live.25$Condition), length(bird.live.26$Condition),
length(bird.live.27$Condition), length(bird.live.28$Condition),
length(bird.live.29$Condition), length(bird.live.30$Condition),
length(bird.live.31$Condition), length(bird.live.32$Condition),
length(bird.live.33$Condition), length(bird.live.34$Condition),
```

```
length(bird.live.35$Condition), length(bird.live.36$Condition),
length(bird.live.37$Condition), length(bird.live.38$Condition),
length(bird.live.39$Condition), length(bird.live.40$Condition) )
z = cbind(x, y)
z = as.data.frame(z)
colnames(z) = c( "Week", "Number" )

u = cbind(rep(19:42))
v = rbind( length(bird.dead.19$Condition), length(bird.dead.20$Condition),
length(bird.dead.21$Condition), length(bird.dead.22$Condition),
length(bird.dead.23$Condition), length(bird.dead.24$Condition),
length(bird.dead.25$Condition), length(bird.dead.26$Condition),
length(bird.dead.27$Condition), length(bird.dead.28$Condition),
length(bird.dead.29$Condition), length(bird.dead.30$Condition),
length(bird.dead.31$Condition), length(bird.dead.32$Condition),
length(bird.dead.33$Condition), length(bird.dead.34$Condition),
length(bird.dead.35$Condition), length(bird.dead.36$Condition),
length(bird.dead.37$Condition), length(bird.dead.38$Condition),
length(bird.dead.39$Condition), length(bird.dead.40$Condition),
length(bird.dead.41$Condition), length(bird.dead.42$Condition) )
w = cbind(u, v)
w = as.data.frame(w)
colnames(w) = c( "Week", "Number" )

fit.live = ts( z[,2], start = 19, end = 40 )
fit.dead = ts( w[,2], start = 19, end = 42 )

pdf(file = "Bird_TimeSeries.pdf",width=11,height=8,pointsize = 12,bg = "white")
plot( fit.dead, xlab = "Weeks of 2010", ylab="Bird Count", xlim=c(16,42), xaxt='n',
main="Observed dead and alive bird counts" )
axis(1, c(16:42))
lines(fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=1.8 )
text(17, 25, "April 20, \n2010", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=1.8 )
text(29, 25, "July 15, \n2010", col = "blue")
legend( "topright", c("Dead birds", "Alive birds","Wellhead blowout",
"Wellhead capped"), lty=c(1,5,3,3), lwd = c(1,1.8,1.8,1.8), cex=1,
col = c("black","green","blue","red") )
dev.off()
```

B.3.3 R Code for Figure 16

```
library(fields)

rm(list=ls())
source("BirdDataReading.R")

# ==================== Accipitriformes
x1 = rbind( 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0 )

y1 = c()
for( i in 19:42){
y1 = c(y1, length( BiOrderCondWeek( Data=Accipitriformes, Condition="Dead",
Week = i )$Condition ) )
y1
}
y1 = as.matrix(y1)

Accipitriformes.fit.live = ts( x1, start = 19, end = 40 )
Accipitriformes.fit.dead = ts( y1, start = 19, end = 40 )


# ==================== Anseriformes
x2 = c()
for( i in 19:40){
x2 = c(x2, length( BiOrderCondWeek( Data=Anseriformes, Condition="Live",
Week = i )$Condition ) )
x2
}
x2 = as.matrix(x2)

y2 = c()
for( i in 19:42){
y2 = c(y2, length( BiOrderCondWeek( Data=Anseriformes, Condition="Dead",
Week = i )$Condition ) )
y2
}
y2 = as.matrix(y2)

Anseriformes.fit.live = ts( x2, start = 19, end = 40 )
Anseriformes.fit.dead = ts( y2, start = 19, end = 42 )



# ==================== Caprimulgiformes
x3 = rbind( 0,0,0,0,0,0,0,0,0,
length(BiOrderCondWeek( Data=Anseriformes, Condition="Live",Week = "28" )$Condition),
0,0,0,0,0,0,0,0,0,0,0,0 )
```

```
y3 = rbind( 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0 )

Caprimulgiformes.fit.live = ts( x3, start = 19, end = 40 )
Caprimulgiformes.fit.dead = ts( y3, start = 19, end = 42 )


# ==================== Charadriiformes
# it takes time to run !!!
x4 = c()
for( i in 19:40){
x4 = c(x4, length( BiOrderCondWeek( Data=Charadriiformes, Condition="Live",
Week = i )$Condition ) )
x4
}
x4 = as.matrix(x4)

y4 = c()
for( i in 19:42){
y4 = c(y4, length( BiOrderCondWeek( Data=Charadriiformes, Condition="Dead",
Week = i )$Condition ) )
y4
}
y4 = as.matrix(y4)

Charadriiformes.fit.live = ts( x4, start = 19, end = 40 )
Charadriiformes.fit.dead = ts( y4, start = 19, end = 42 )


# ==================== Ciconiiformes
x5 = c()
for( i in 19:40){
x5 = c(x5, length( BiOrderCondWeek( Data=Ciconiiformes, Condition="Live",
Week = i )$Condition ) )
x5
}
x5 = as.matrix(x5)

y5 = c()
for( i in 19:42){
y5 = c(y5, length( BiOrderCondWeek( Data=Ciconiiformes, Condition="Dead",
Week = i )$Condition ) )
y5
}
y5 = as.matrix(y5)

Ciconiiformes.fit.live = ts( x5, start = 19, end = 40 )
Ciconiiformes.fit.dead = ts( y5, start = 19, end = 42 )
```

```
# ==================== Columbiformes
x6 = c()
for( i in 19:40){
x6 = c(x6, length( BiOrderCondWeek( Data=Columbiformes, Condition="Live",
Week = i )$Condition ) )
x6
}
x6 = as.matrix(x6)

y6 = c()
for( i in 19:42){
y6 = c(y6, length( BiOrderCondWeek( Data=Columbiformes, Condition="Dead",
Week = i )$Condition ) )
y6
}
y6 = as.matrix(y6)

Columbiformes.fit.live = ts( x6, start = 19, end = 40 )
Columbiformes.fit.dead = ts( y6, start = 19, end = 42 )


# ==================== Coraciiformes
x7 = c()
for( i in 19:40){
x7 = c(x7, length( BiOrderCondWeek( Data=Coraciiformes, Condition="Live",
Week = i )$Condition ) )
x7
}
x7 = as.matrix(x7)

y7 = c()
for( i in 19:42){
y7 = c(y7, length( BiOrderCondWeek( Data=Coraciiformes, Condition="Dead",
Week = i )$Condition ) )
y7
}
y7 = as.matrix(y7)

Coraciiformes.fit.live = ts( x7, start = 19, end = 40 )
Coraciiformes.fit.dead = ts( y7, start = 19, end = 42 )


# ==================== Cuculiformes
x8 = rbind( 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0 )
```

```
y8 = c()
for( i in 19:42){
y8 = c(y8, length( BiOrderCondWeek( Data=Cuculiformes, Condition="Dead",
Week = i )$Condition ) )
y8
}
y8 = as.matrix(y8)

Cuculiformes.fit.live = ts( x8, start = 19, end = 40 )
Cuculiformes.fit.dead = ts( y8, start = 19, end = 42 )


# ==================== Falconiformes
x9 = c()
for( i in 19:40){
x9 = c(x9, length( BiOrderCondWeek( Data=Falconiformes, Condition="Live",
Week = i )$Condition ) )
x9
}
x9 = as.matrix(x9)

y9 = c()
for( i in 19:42){
y9 = c(y9, length( BiOrderCondWeek( Data=Falconiformes, Condition="Dead",
Week = i )$Condition ) )
y9
}
y9 = as.matrix(y9)

Falconiformes.fit.live = ts( x9, start = 19, end = 40 )
Falconiformes.fit.dead = ts( y9, start = 19, end = 42 )


# ==================== Gaviiformes
x10 = c()
for( i in 19:40){
x10 = c(x10, length( BiOrderCondWeek( Data=Gaviiformes, Condition="Live",
Week = i )$Condition ) )
x10
}
x10 = as.matrix(x10)

y10 = c()
for( i in 19:42){
y10 = c(y10, length( BiOrderCondWeek( Data=Gaviiformes, Condition="Dead",
Week = i )$Condition ) )
y10
```

```
}
y10 = as.matrix(y10)

Gaviiformes.fit.live = ts( x10, start = 19, end = 40 )
Gaviiformes.fit.dead = ts( y10, start = 19, end = 42 )


# ==================== Gruiformes
x11 = c()
for( i in 19:40){
x11 = c(x11, length( BiOrderCondWeek( Data=Gruiformes, Condition="Live",
Week = i )$Condition ) )
x11
}
x11 = as.matrix(x11)

y11 = c()
for( i in 19:42){
y11 = c(y11, length( BiOrderCondWeek( Data=Gruiformes, Condition="Dead",
Week = i )$Condition ) )
y11
}
y11 = as.matrix(y11)

Gruiformes.fit.live = ts( x11, start = 19, end = 40 )
Gruiformes.fit.dead = ts( y11, start = 19, end = 42 )


# ==================== Passeriformes
x12 = c()
for( i in 19:40){
x12 = c(x12, length( BiOrderCondWeek( Data=Passeriformes, Condition="Live",
Week = i )$Condition ) )
x12
}
x12 = as.matrix(x12)

y12 = c()
for( i in 19:42){
y12 = c(y12, length( BiOrderCondWeek( Data=Passeriformes, Condition="Dead",
Week = i )$Condition ) )
y12
}
y12 = as.matrix(y12)

Passeriformes.fit.live = ts( x12, start = 19, end = 40 )
Passeriformes.fit.dead = ts( y12, start = 19, end = 42 )
```

```
# ==================== Pelecaniformes
# it takes time to run !!!
x13 = c()
for( i in 19:40){
x13 = c(x13, length( BiOrderCondWeek( Data=Pelecaniformes, Condition="Live",
Week = i )$Condition ) )
x13
}
x13 = as.matrix(x13)

y13 = c()
for( i in 19:42){
y13 = c(y13, length( BiOrderCondWeek( Data=Pelecaniformes, Condition="Dead",
Week = i )$Condition ) )
y13
}
y13 = as.matrix(y13)

Pelecaniformes.fit.live = ts( x13, start = 19, end = 40 )
Pelecaniformes.fit.dead = ts( y13, start = 19, end = 42 )


# ==================== Podicipediformes
x14 = c()
for( i in 19:40){
x14 = c(x14, length( BiOrderCondWeek( Data=Podicipediformes, Condition="Live",
Week = i )$Condition ) )
x14
}
x14 = as.matrix(x14)

y14 = c()
for( i in 19:42){
y14 = c(y14, length( BiOrderCondWeek( Data=Podicipediformes, Condition="Dead",
Week = i )$Condition ) )
y14
}
y14 = as.matrix(y14)

Podicipediformes.fit.live = ts( x14, start = 19, end = 40 )
Podicipediformes.fit.dead = ts( y14, start = 19, end = 42 )


# ==================== Procellariiformes
x15 = c()
```

```
for( i in 19:40){
x15 = c(x15, length( BiOrderCondWeek( Data=Procellariiformes, Condition="Live",
Week = i )$Condition ) )
x15
}
x15 = as.matrix(x15)

y15 = c()
for( i in 19:42){
y15 = c(y15, length( BiOrderCondWeek( Data=Procellariiformes, Condition="Dead",
Week = i )$Condition ) )
y15
}
y15 = as.matrix(y15)

Procellariiformes.fit.live = ts( x15, start = 19, end = 40 )
Procellariiformes.fit.dead = ts( y15, start = 19, end = 42 )


# ==================== Stigiformes
x16 = rbind( 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0 )

y16 = c()
for( i in 19:42){
y16 = c(y16, length( BiOrderCondWeek( Data=Stigiformes, Condition="Dead",
Week = i )$Condition ) )
y16
}
y16 = as.matrix(y16)

Stigiformes.fit.live = ts( x16, start = 19, end = 40 )
Stigiformes.fit.dead = ts( y16, start = 19, end = 42 )


# ==================== Other
x17 = c()
for( i in 19:40){
x17 = c(x17, length( BiOrderCondWeek( Data=Other, Condition="Live",
Week = i )$Condition ) )
x17
}
x17 = as.matrix(x17)

y17 = c()
for( i in 19:42){
y17 = c(y17, length( BiOrderCondWeek( Data=Other, Condition="Dead",
Week = i )$Condition ) )
```

```
y17
}
y17 = as.matrix(y17)

Other.fit.live = ts( x17, start = 19, end = 40 )
Other.fit.dead = ts( y17, start = 19, end = 42 )


# ==================== Unknown
x18 = c()
for( i in 19:40){
x18 = c(x18, length( BiOrderCondWeek( Data=Unknown, Condition="Live",
Week = i )$Condition ) )
x18
}
x18 = as.matrix(x18)

y18 = c()
for( i in 19:42){
y18 = c(y18, length( BiOrderCondWeek( Data=Unknown, Condition="Dead",
Week = i )$Condition ) )
y18
}
y18 = as.matrix(y18)

Unknown.fit.live = ts( x18, start = 19, end = 40 )
Unknown.fit.dead = ts( y18, start = 19, end = 42 )




# ======================== Multivariate Time Series =========================== #
pdf(file = "BirdBiologycal_TimeSeries.pdf",width=10,height=20,pointsize = 12,bg = "white")
m <- matrix(c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,19,19),
nrow = 7,ncol = 3,byrow = TRUE)
layout( mat = m, heights = c(0.175,0.175,0.175,0.175,0.175,0.175,0.1) )

# ------------- Accipitriformes -------------- #
par(mar = c(4.5,4.5,2,1), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Accipitriformes.fit.dead, xlab = "Weeks of 2010", ylab="Bird Count",
yaxt='n', ylim=c(0,1.1), xlim=c(16,42), xaxt='n', main = "Accipitriformes" )
axis(1, c(16:42))
axis(2, c(0,1))
lines(Accipitriformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.05, "04/20", col = "blue")
```

```
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.05, "07/15", col = "red")

# ------------- Anseriformes -------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Anseriformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
yaxt='n', ylim=c(0,13), xlim=c(16,42), xaxt='n', main = "Anseriformes" )
axis(1, c(16:42))
axis(2, c(0,3,6,9,12))
lines(Anseriformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.5, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.5, "07/15", col = "red")

# ------------- Caprimulgiformes -------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Caprimulgiformes.fit.live, ylab=NA, xlab = "Weeks of 2010",
col="green", lty=5, lwd=1.8,
yaxt='n', ylim=c(0,1.1), xlim=c(16,42), xaxt='n', main = "Caprimulgiformes" )
axis(1, c(16:42))
axis(2, c(0,1))
lines(Caprimulgiformes.fit.dead)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.1, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.1, "07/15", col = "red")

# ------------- Charadriiformes -------------- #
par(mar = c(4.5,4.5,2,1), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Charadriiformes.fit.dead, xlab = "Weeks of 2010", ylab="Bird Count",
xlim=c(16,42), xaxt='n', main = "Charadriiformes" )
axis(1, c(16:42))
lines(Charadriiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 15, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 15, "07/15", col = "red")

# ------------- Ciconiiformes -------------- #
```

```
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Ciconiiformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
yaxt='n', ylim=c(0,35), xlim=c(16,42), xaxt='n', main = "Ciconiiformes" )
axis(1, c(16:42))
axis(2, c(0,10,20,30))
yaxt='n', ylim=c(0,1.1),
lines(Ciconiiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 1, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 1, "07/15", col = "red")

# -------------- Columbiformes --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Columbiformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
xlim=c(16,42), xaxt='n', main = "Columbiformes" )
axis(1, c(16:42))
lines(Columbiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.15, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.15, "07/15", col = "red")

# -------------- Coraciiformes --------------- #
par(mar = c(4.5,4.5,2,1), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Coraciiformes.fit.dead, xlab = "Weeks of 2010", ylab="Bird Count",
yaxt='n', ylim=c(0,1.1), xlim=c(16,42), xaxt='n', main = "Coraciiformes" )
axis(1, c(16:42))
axis(2, c(0,1))
lines(Coraciiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.05, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.05, "07/15", col = "red")

# -------------- Cuculiformes --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Cuculiformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
yaxt='n', ylim=c(0,1.1), xlim=c(16,42), xaxt='n', main = "Cuculiformes" )
axis(1, c(16:42))
axis(2, c(0,1))
```

```
lines(Cuculiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.05, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.05, "07/15", col = "red")

# -------------- Falconiformes --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Falconiformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
xlim=c(16,42), xaxt='n', main = "Falconiformes" )
axis(1, c(16:42))
lines(Falconiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.1, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.1, "07/15", col = "red")

# -------------- Gaviiformes --------------- #
par(mar = c(4.5,4.5,2,1), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Gaviiformes.fit.dead, xlab = "Weeks of 2010", ylab="Bird Count",
xlim=c(16,42), xaxt='n', main = "Gaviiformes" )
axis(1, c(16:42))
lines(Gaviiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.5, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.5, "07/15", col = "red")

# -------------- Gruiformes --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Gruiformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
yaxt='n', ylim=c(0,13), xlim=c(16,42), xaxt='n', main = "Gruiformes" )
axis(1, c(16:42))
axis(2, c(0,3,6,9,12))
lines(Gruiformes.fit.live,col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.4, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.4, "07/15", col = "red")
```

```
# -------------- Passeriformes --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Passeriformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
xlim=c(16,42), xaxt='n', main = "Passeriformes" )
axis(1, c(16:42))
lines(Passeriformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.4, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.4, "07/15", col = "red")

# -------------- Pelecaniformes --------------- #
par(mar = c(4.5,4.5,2,1), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Pelecaniformes.fit.live, xlab = "Weeks of 2010", ylab="Bird Count",
col="green", lty=5, lwd=1.8,
xlim=c(16,42), xaxt='n', main = "Pelecaniformes" )
axis(1, c(16:42))
lines(Pelecaniformes.fit.dead)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 2, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 2, "07/15", col = "red")

# -------------- Podicipediformes --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Podicipediformes.fit.live, ylab=NA, xlab = "Weeks of 2010",
col="green", lty=5, lwd=1.8,
yaxt='n', ylim=c(0,13), xlim=c(16,42), xaxt='n', main = "Podicipediformes" )
axis(1, c(16:42))
axis(2, c(0,3,6,9,12))
lines(Podicipediformes.fit.dead)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.5, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.5, "07/15", col = "red")

# -------------- Procellariiformes --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Procellariiformes.fit.dead, ylab=NA, xlab = "Weeks of 2010",
xlim=c(16,42), xaxt='n', main = "Procellariiformes" )
```

```
axis(1, c(16:42))
lines(Procellariiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.15, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.15, "07/15", col = "red")

# -------------- Stigiformes --------------- #
par(mar = c(4.5,4.5,2,1), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Stigiformes.fit.dead, xlab = "Weeks of 2010", ylab="Bird Count",
yaxt='n', ylim=c(0,1.1), xlim=c(16,42), xaxt='n', main = "Stigiformes" )
axis(1, c(16:42))
axis(2, c(0,1))
lines(Stigiformes.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.04, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 0.04, "07/15", col = "red")

# -------------- Unknown --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Unknown.fit.dead, ylab=NA, xlab = "Weeks of 2010",
xlim=c(16,42), xaxt='n', main = "Unknown" )
axis(1, c(16:42))
lines(Unknown.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 2, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
text(29, 2, "07/15", col = "red")

# -------------- Other --------------- #
par(mar = c(4.5,3,2,1.5), cex.main = 1.7, cex.axis=1.7, cex.lab=1.7)
plot( Other.fit.dead, ylab=NA, xlab = "Weeks of 2010",
xlim=c(16,42), xaxt='n', main = "Other" )
axis(1, c(16:42))
lines(Other.fit.live, col="green", lty=5, lwd=1.8)
# The Oil spill happened on April 20, 2010 (week 16)
xline( 17, col="blue", lty=3, lwd=2 )
text(17, 0.5, "04/20", col = "blue")
# The oil head was capped on July 15, 2010 (week 29)
xline( 29, col="red", lty=3, lwd=2 )
```

```
text(29, 0.5, "07/15", col = "red")

plot(1, type = "n", axes=FALSE, xlab="", ylab="")
legend( x = "top", inset = 0,
        legend = c("Dead birds", "Alive birds","Wellhead blowout","Wellhead capped"),
        title = "Observed dead and alive birds by biologycal orders:",
col=c("black", "green","blue","red"), lty=c(1,5,3,3,0), cex=1.7,
lwd = c(1,1.8,2,2), horiz = TRUE )

dev.off()
```

B.3.4 R Code for Figure 22

```
library(ggplot2)

source("BirdDataReading.R")

label_renamemargin_gen <- function(newname="Total") {
  function(variable, value) {
    value <- as.character(value)
    value[value == "(all)"] <- newname
    value
  }
}

d = ggplot(bird, aes(BiologicalOrder)) +
    geom_point(stat="bin", size = 3, aes(shape = Condition, position = "stack")) +
coord_flip() +
facet_grid(Condition ~ Oiling, margins=TRUE,labeller = label_renamemargin_gen("Total") ) +
labs( x="Biological Orders", y="Counts" ) +
opts( title = "Oiling and Living Status",
axis.text.x = theme_text(colour = "black"),
axis.text.y = theme_text(colour = "black") ) + theme_bw() +
scale_shape_discrete( solid = FALSE, name ="Living Status:",
c("Dead", "Live", "(all)"), labels=c("Dead", "Live", "Total") )

pdf(file = "BiologicalOrders_dotplot.pdf",width=10,height=10,pointsize = 12,bg = "white")
d + scale_x_discrete(limits=c( "Accipitriformes",  "Caprimulgiformes", "Stigiformes",
"Coraciiformes", "Cuculiformes", "Falconiformes", "Passeriformes", "Podicipediformes",
"Procellariiformes", "Columbiformes", "Anseriformes", "Gaviiformes",
"Gruiformes", "Other", "Ciconiiformes", "Unknown", "Pelecaniformes", "Charadriiformes"))
dev.off()
```

B.3.5 R Code for Figure 23

```
library(ggplot2)

source("BirdDataReading.R")

label_renamemargin_gen <- function(newname="Total") {
  function(variable, value) {
    value <- as.character(value)
    value[value == "(all)"] <- newname
    value
  }
}

d1 = ggplot(Charadriiformes, aes(Species)) +
    geom_point(stat="bin", size = 3, aes(shape = Condition, position = "stack")) +
coord_flip() +
facet_grid(Condition ~ Oiling, margins=TRUE,labeller = label_renamemargin_gen("Total") ) +
labs( x="Bird Species", y="Counts" ) +
opts( title = "Oiling and Living Status",
axis.text.x = theme_text(colour = "black"),
axis.text.y = theme_text(colour = "black") ) + theme_bw() +
scale_shape_discrete( solid = FALSE, name ="Living Status:",
c("Dead", "Live", "(all)"), labels=c("Dead", "Live", "Total") )


pdf(file = "Charadriiformes_dotplot.pdf",width=13,height=13,pointsize = 12,bg = "white")
d1 + scale_x_discrete(limits=c( "Black Oystercatcher", "Black Tern", "Black-necked Stilt",
"Blue-winged Teal","Gull-billed Tern","Killdeer", "Lesser Black-backed Gull",
"Long-Billed Dowitcher","Piping Plover", "Ring-billed Gull", "Semipalmated Sandpiper",
"Short-billed Dowitcher", "Sooty Tern", "Wilson's Plover","Spotted Sandpiper",
"Unidentified Dowitcher",  "Unidentified Sandpiper", "Unidentified Shorebird",
"Unidentified Skimmer", "Willet", "Ruddy Turnstone", "American Oystercatcher",
"Caspian Tern", "Common Tern","Sanderling", "Herring Gull", "Forster's Tern",
"Sandwich Tern", "Least Tern","Unidentified Tern", "Unidentified Gull",
"Black Skimmer","Royal Tern", "Laughing Gull" ))
dev.off()
```

B.3.6 R Code for Figure 24

```
library(ggplot2)

source("BirdDataReading.R")
```

```
label_renamemargin_gen <- function(newname="Total") {
  function(variable, value) {
    value <- as.character(value)
    value[value == "(all)"] <- newname
    value
  }
}

d3 = ggplot(Pelecaniformes, aes(Species)) +
    geom_point(stat="bin", size = 3, aes(shape = Condition, position = "stack")) +
coord_flip() +
facet_grid(Condition ~ Oiling, margins=TRUE,labeller = label_renamemargin_gen("Total") ) +
labs( x="Bird Species", y="Counts" ) +
opts( title = "Oiling and Living Status",
axis.text.x = theme_text(colour = "black"),
axis.text.y = theme_text(colour = "black") ) + theme_bw() +
scale_shape_discrete( solid = FALSE, name ="Living Status:",
c("Dead", "Live", "(all)"), labels=c("Dead", "Live", "Total") )

p = ggplot(Pelecaniformes, aes(Species, fill=Oiling)) +
    geom_point(stat="bin", size = 4, aes(shape = Oiling, position = "stack")) + #colour = Oiling
coord_flip()+ scale_shape(solid = FALSE) + labs( x="Bird Species", y="Counts" ) +
facet_grid(Condition ~ .) +
opts(title = "Pelecaniformes Biological Order", strip.text.y = theme_text())

pdf(file = "Pelecaniformes_dotplot.pdf",width=12,height=8,pointsize = 12,bg = "white")
d3 + scale_x_discrete(limits=c("Neotropic Cormorant", "Magnificent Frigatebird", "Masked Booby",
"Unidentified Egret","Unidentified Cormorant", "American White Pelican",
"Double-crested Cormorant","Unidentified Pelican","Northern Gannet","Brown Pelican"))
dev.off()
```

B.3.7 R Code for Figure 17

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/5_BIRD")

rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
# library(rgdal)

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
```

```
source("BirdDataReading.R")

bb <- qbbox(c(28,29,30), c(-92.2,-87,-85.6),TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")


# ============================= MAY ==========================================#
#jpeg("Google_OilingCondMonth_May.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 31, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100531_1558\\20100531_1558_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-05" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-05" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-05" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-05" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Dead", Month = "2010-05" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
```

```
L6 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Live", Month = "2010-05" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="May 2010:")
text( 200, -225, "Oil spill area \n for May 31, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

#dev.off()


# ============================== JUNE ==========================================#
jpeg("Google_OilingCondMonth_June.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 27, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100627_1148\\20100627_1148_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Dead", Month = "2010-06" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Live", Month = "2010-06" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="June 2010:")
text( 200, -225, "Oil spill area \n for June 27, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== JULY ==========================================#
jpeg("Google_OilingCondMonth_July.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for July 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100725_1617\\20100725_1617.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )
```

```
# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Dead", Month = "2010-07" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Live", Month = "2010-07" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="July 2010:")
text( 200, -225, "Oil spill area \n for July 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )
text( 100, -280, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ============================== AUGUST =========================================#
jpeg("Google_OilingCondMonth_Aug.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100825composite\\20100825_composite.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-08" )
```

```
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-08" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Dead", Month = "2010-08" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Live", Month = "2010-08" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="August 2010:")
text( 200, -225, "Oil spill area \n for August 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== SEPTEMBER =========================================#
jpeg("Google_OilingCondMonth_Sep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
```

```
L2 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Dead", Month = "2010-09" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Live", Month = "2010-09" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="September 2010:")

dev.off()




# ============================== OCTOBER ==========================================#
jpeg("Google_OilingCondMonth_Oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-10" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )
```

```
# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-10" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-10" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-10" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Dead", Month = "2010-10" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=bird, Oiling = "Unknown", Condition="Live", Month = "2010-10" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="October 2010:")

dev.off()
```

B.3.8 R Code for Figures 18, 19, 20, and 21

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/5_BIRD")

rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)
```

```
source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))

source("BirdDataReading.R")

bb <- qbbox(c(28,29,30), c(-92.2,-87,-85.6),TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")


# ============================== Week 19 ==========================================#
jpeg("Google_OilingCondWeek19.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 9, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100509_1550\\20100509_1550_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "19" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "19" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "19" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "19" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "19" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )
```

```
# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "19" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for May 9, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 20 ==========================================#
jpeg("Google_OilingCondWeek20.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 10, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100510_2353\\20100510_2353_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "20" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "20" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "20" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "20" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
```

```
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "20" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "20" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for May 10, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 21 ==========================================#
jpeg("Google_OilingCondWeek21.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 27, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100527_2357\\20100527_2357_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "21" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "21" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "21" )
```

```
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "21" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "21" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "21" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for May 27, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 22 ==========================================#
jpeg("Google_OilingCondWeek22.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 31, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100531_1558\\20100531_1558_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "22" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
```

```
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "22" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "22" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "22" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "22" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "22" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for May 31, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 23 ==========================================#
jpeg("Google_OilingCondWeek23.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 6, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100606_0349\\20100606_0349.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )
```

```
# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "23" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "23" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "23" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "23" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "23" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "23" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for June 6, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 24 ==========================================#
jpeg("Google_OilingCondWeek24.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 12, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100612_1851\\20100612_1851.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
```

```
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "24" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "24" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "24" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "24" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "24" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "24" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for June 12, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 25 ==========================================#
```

```
jpeg("Google_OilingCondWeek25.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 19, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100619_2338\\20100619_2338.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "25" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "25" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "25" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "25" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "25" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "25" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
```

```
text( 200, -225, "Oil spill area \n for June 19, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 26 ==========================================#
jpeg("Google_OilingCondWeek26.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 27, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100627_1148\\20100627_1148_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "26" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "26" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "26" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "26" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "26" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "26" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )
```

```
legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for June 27, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================= Week 27 =========================================#
jpeg("Google_OilingCondWeek27.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for July 4, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100704_1637\\20100704_1637.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "27" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "27" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "27" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "27" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "27" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
```

```
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "27" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for July 4, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================= Week 28 =========================================#
jpeg("Google_OilingCondWeek28.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for July 11, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100711_0349\\20100711_0349.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "28" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "28" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "28" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "28" )
```

```
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "28" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "28" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white")
text( 200, -225, "Oil spill area \n for July 11, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 29 ==========================================#
jpeg("Google_OilingCondWeek29.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for July 18, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100718_1549\\20100718_1549.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "29" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "29" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
```

```
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "29" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "29" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "29" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "29" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for July 18, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )
text( 100, -280, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ============================== Week 30 ==========================================#
jpeg("Google_OilingCondWeek30.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for July 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100725_1617\\20100725_1617.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "30" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )
```

```
# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "30" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "30" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "30" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "30" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "30" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for July 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================= Week 31 ========================================#
jpeg("Google_OilingCondWeek31.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 1, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100801_0001\\20100801_0001.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
```

```
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "31" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "31" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "31" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "31" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "31" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "31" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for August 1, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 32 ==========================================#
jpeg("Google_OilingCondWeek32.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 8, 2010
```

```
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100808_2356\\20100808_2356.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "32" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "32" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "32" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "32" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "32" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "32" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for August 8, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```

```
# ============================= Week 33 =========================================#
jpeg("Google_OilingCondWeek33.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 18, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100818composite\\20100818_composite.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "33" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "33" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "33" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "33" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "33" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "33" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
```

```
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for August 18, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================= Week 34 =========================================#
jpeg("Google_OilingCondWeek34.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 21, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100821composite\\20100821_composite.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "34" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "34" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "34" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "34" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "34" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "34" )
```

```
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for August 21, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 35 ==========================================#
jpeg("Google_OilingCondWeek35.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100825composite\\20100825_composite.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "35" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "35" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "35" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "35" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )

# Dead, Oiling Status Unknown
```

```
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "35" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "35" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )
text( 200, -225, "Oil spill area \n for August 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== Week 36 ==========================================#
jpeg("Google_OilingCondWeek36.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "36" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "36" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "36" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "36" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "36" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "36" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )

dev.off()


# ============================== Week 37 ==========================================#
jpeg("Google_OilingCondWeek37.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "37" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "37" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "37" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "37" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "37" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "37" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )

dev.off()


# ============================== Week 38 ==========================================#
jpeg("Google_OilingCondWeek38.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "38" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "38" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "38" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "38" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "38" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "38" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )

dev.off()


# ============================== Week 39 ==========================================#
jpeg("Google_OilingCondWeek39.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "39" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "39" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "39" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "39" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "39" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "39" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )

dev.off()


# ============================== Week 40 ==========================================#
jpeg("Google_OilingCondWeek40.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "40" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "40" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "40" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "40" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "40" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "40" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )

dev.off()


# ============================== Week 41 ==========================================#
jpeg("Google_OilingCondWeek41.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "41" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "41" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "41" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "41" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "41" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "41" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )

dev.off()


# ============================== Week 42 ==========================================#
jpeg("Google_OilingCondWeek42.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Dead", Week = "42" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondWeek( Data=bird, Oiling = "Visibly Oiled", Condition="Live", Week = "42" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.5, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Dead", Week = "42" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondWeek( Data=bird, Oiling = "Not Visibly Oiled", Condition="Live", Week = "42" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.5, col = "red", add = T )
```

```
# Dead, Oiling Status Unknown
L5 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Dead", Week = "42" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondWeek( Data=bird, Oiling = "Unknown", Condition="Live", Week = "42" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.5, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.535,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Birds",
"Live Birds","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white" )

dev.off()
```

B.3.9 R Code for Figure 25

```
library(ggplot2)

source("BirdDataReading.R")

label_renamemargin_gen <- function(newname="Total") {
  function(variable, value) {
    value <- as.character(value)
    value[value == "(all)"] <- newname
    value
  }
}

d2 = ggplot(LaughingGull, aes(Month)) +
    geom_point(stat="bin", size = 3, aes(shape = Condition, position = "stack")) +
coord_flip() +
facet_grid(Condition ~ Oiling, margins=TRUE,labeller = label_renamemargin_gen("Total") ) +
labs( x="Months", y="Counts" ) +
opts( title = "Oiling and Living Status",
axis.text.x = theme_text(colour = "black"),
axis.text.y = theme_text(colour = "black") ) + theme_bw() +
scale_shape_discrete( solid = FALSE, name ="Living Status:",
c("Dead", "Live", "(all)"), labels=c("Dead", "Live", "Total") )
```

```
pdf(file = "LaughingGull_dotplot.pdf",width=9,height=6,pointsize = 12,bg = "white")
d2 + opts(axis.text.x = theme_text(angle = 90)) +
scale_x_discrete(limits=c("October","September","August","July","June","May"))
dev.off()
```

B.3.10 R Code for Figure 26

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/5_BIRD")

rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)
library(ggplot2)
#library(gplots) # to read.xls

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))

source("BirdDataReading.R")

# -------------- Google -----------------#

bb <- qbbox(c(28,29,30), c(-92.2,-87,-85.6),TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")


# ============================== MAY ==========================================#
jpeg("LaughingGull_Google_May.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 31, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100531_1558\\20100531_1558_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-05" )
```

```
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-05" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-05" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-05" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Dead", Month = "2010-05" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Live", Month = "2010-05" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Laughing Gull",
"Live Laughing Gull","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="May 2010:")
text( 200, -225, "Oil spill area \n for May 31, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== JUNE ==========================================#
jpeg("LaughingGull_Google_June.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 27, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100627_1148\\20100627_1148_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)
```

```
# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Dead", Month = "2010-06" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Live", Month = "2010-06" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Laughing Gull",
"Live Laughing Gull","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="June 2010:")
text( 200, -225, "Oil spill area \n for June 27, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== JULY ==========================================#
jpeg("LaughingGull_Google_July.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)
```

```
# Oil Spill area for July 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100725_1617\\20100725_1617.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Dead", Month = "2010-07" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Live", Month = "2010-07" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Laughing Gull",
"Live Laughing Gull","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="July 2010:")
text( 200, -225, "Oil spill area \n for July 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )
text( 100, -280, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )
```

```
dev.off()


# ============================== AUGUST ==========================================#
jpeg("LaughingGull_Google_Aug.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100825composite\\20100825_composite.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-08" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-08" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Dead", Month = "2010-08" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Live", Month = "2010-08" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )
```

```
legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Laughing Gull",
"Live Laughing Gull","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="August 2010:")
text( 200, -225, "Oil spill area \n for August 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== SEPTEMBER ==========================================#
jpeg("LaughingGull_Google_Sep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Dead", Month = "2010-09" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Live", Month = "2010-09" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )
```

```
legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Laughing Gull",
"Live Laughing Gull","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="September 2010:")

dev.off()



# ============================== OCTOBER =========================================#
jpeg("LaughingGull_Google_Oct.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-10" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=LaughingGull, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-10" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-10" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=LaughingGull, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-10" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Dead", Month = "2010-10" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=LaughingGull, Oiling = "Unknown", Condition="Live", Month = "2010-10" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
```

```
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Laughing Gull",
"Live Laughing Gull","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="October 2010:")

dev.off()
```

B.3.11 R Code for Figure 27

```
library(ggplot2)

source("BirdDataReading.R")

label_renamemargin_gen <- function(newname="Total") {
  function(variable, value) {
    value <- as.character(value)
    value[value == "(all)"] <- newname
    value
  }
}

d4 = ggplot(LaughingGull, aes(Month)) +
    geom_point(stat="bin", size = 3, aes(shape = Condition, position = "stack")) +
coord_flip() +
facet_grid(Condition ~ Oiling, margins=TRUE,labeller = label_renamemargin_gen("Total") ) +
labs( x="Months", y="Counts" ) +
opts( title = "Oiling and Living Status",
axis.text.x = theme_text(colour = "black"),
axis.text.y = theme_text(colour = "black") ) + theme_bw() +
scale_shape_discrete( solid = FALSE, name ="Living Status:",
c("Dead", "Live", "(all)"), labels=c("Dead", "Live", "Total") )

pdf(file = "BrownPelican_dotplot.pdf",width=9,height=6,pointsize = 12,bg = "white")
d4 + opts(axis.text.x = theme_text(angle = 90)) +
scale_x_discrete(limits=c("October","September","August","July","June","May"))
dev.off()
```

B.3.12 R Code for Figure 28

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/5_BIRD")

#rm(list=ls())

library(RgoogleMaps)
library(PBSmapping)
library(RColorBrewer)
library(rgdal)
library(ggplot2)
#library(gplots) # to read.xls

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))

source("BirdDataReading.R")


# -------------- Google -----------------#

bb <- qbbox(c(28,29,30), c(-92.2,-87,-85.6),TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")


# ============================== MAY ==========================================#
jpeg("BrownPelican_Google_May.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 31, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100531_1558\\20100531_1558_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-05" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-05" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )
```

```
# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-05" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-05" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Dead", Month = "2010-05" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Live", Month = "2010-05" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Brown Pelican",
"Live Brown Pelican","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="May 2010:")
text( 200, -225, "Oil spill area \n for May 31, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== JUNE ==========================================#
jpeg("BrownPelican_Google_June.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 27, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100627_1148\\20100627_1148_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )
```

```
# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Dead", Month = "2010-06" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Live", Month = "2010-06" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Brown Pelican",
"Live Brown Pelican","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="June 2010:")
text( 200, -225, "Oil spill area \n for June 27, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== JULY ==========================================#
jpeg("BrownPelican_Google_July.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for July 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100725_1617\\20100725_1617.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
```

```
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Dead", Month = "2010-07" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Live", Month = "2010-07" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Brown Pelican",
"Live Brown Pelican","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="July 2010:")
text( 200, -225, "Oil spill area \n for July 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )
text( 100, -280, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ============================= AUGUST =========================================#
jpeg("BrownPelican_Google_Aug.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)
```

```
# Oil Spill area for August 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100825composite\\20100825_composite.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-08" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-08" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Dead", Month = "2010-08" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Live", Month = "2010-08" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Brown Pelican",
"Live Brown Pelican","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="August 2010:")
text( 200, -225, "Oil spill area \n for August 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```

```
# ============================== SEPTEMBER ==========================================#
jpeg("BrownPelican_Google_Sep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=BrownPelican, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=BrownPelican, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Dead", Month = "2010-09" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=BrownPelican, Oiling = "Unknown", Condition="Live", Month = "2010-09" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Brown Pelican",
"Live Brown Pelican","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="September 2010:")

dev.off()
```

```
# NO DATA for OCTOBER
```

B.3.13 R Code for Figure 29

```
library(ggplot2)

source("BirdDataReading.R")

label_renamemargin_gen <- function(newname="Total") {
  function(variable, value) {
    value <- as.character(value)
    value[value == "(all)"] <- newname
    value
  }
}

d5 = ggplot(NorthernGannet, aes(Month)) +
    geom_point(stat="bin", size = 3, aes(shape = Condition, position = "stack")) +
coord_flip() +
facet_grid(Condition ~ Oiling, margins=TRUE,labeller = label_renamemargin_gen("Total") ) +
labs( x="Months", y="Counts" ) +
opts( title = "Oiling and Living Status",
axis.text.x = theme_text(colour = "black"),
axis.text.y = theme_text(colour = "black") ) + theme_bw() +
scale_shape_discrete( solid = FALSE, name ="Living Status:",
c("Dead", "Live", "(all)"), labels=c("Dead", "Live", "Total") )

pdf(file = "NorthernGannet_dotplot.pdf",width=9,height=6,pointsize = 12,bg = "white")
d5 + scale_x_discrete(limits=c("September","August","July","June","May"))
dev.off()
```

B.3.14 R Code for Figure 30

```
setwd("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/5_BIRD")

rm(list=ls())

library(RgoogleMaps)
```

```
library(PBSmapping)
library(RColorBrewer)
library(rgdal)
library(ggplot2)
#library(gplots) # to read.xls

source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))

source("BirdDataReading.R")

# ------------- Google ----------------#

bb <- qbbox(c(28,29,30), c(-92.2,-87,-85.6),TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")


# ============================= MAY =========================================#
jpeg("NorthernGannet_Google_May.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for May 31, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100531_1558\\20100531_1558_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-05" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-05" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-05" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-05" )
```

```
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Dead", Month = "2010-05" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Live", Month = "2010-05" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Northern Gannet",
"Live Northern Gannet","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="May 2010:")
text( 200, -225, "Oil spill area \n for May 31, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== JUNE ==========================================#
jpeg("NorthernGannet_Google_June.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for June 27, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100627_1148\\20100627_1148_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
```

```
L3 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-06" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-06" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Dead", Month = "2010-06" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Live", Month = "2010-06" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Northern Gannet",
"Live Northern Gannet","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="June 2010:")
text( 200, -225, "Oil spill area \n for June 27, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== JULY ==========================================#
jpeg("NorthernGannet_Google_July.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for July 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100725_1617\\20100725_1617.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )
```

```
# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-07" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-07" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Dead", Month = "2010-07" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Live", Month = "2010-07" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Northern Gannet",
"Live Northern Gannet","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="July 2010:")
text( 200, -225, "Oil spill area \n for July 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )
text( 100, -280, "The Wellhead was capped on 15 July 2010", adj = c(0.5, 0.5), col = "red", cex = 1.2 )

dev.off()


# ============================== AUGUST ==========================================#
jpeg("NorthernGannet_Google_Aug.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil Spill area for August 25, 2010
shpFile <-  'D:\\ ... \\RShapefile\\NOOA\\shapefiles_20100825composite\\20100825_composite.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)

# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
```

```
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-08" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-08" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-08" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Dead", Month = "2010-08" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Live", Month = "2010-08" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Northern Gannet",
"Live Northern Gannet","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="August 2010:")
text( 200, -225, "Oil spill area \n for August 25, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()


# ============================== SEPTEMBER ==========================================#
jpeg("NorthernGannet_Google_Sep.jpg", width=7.5, height=7.5, units="in", res=90)
PlotOnStaticMap(MyMap)

# Oil spill location
```

```
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

# Dead, Visibly Oiled
L1 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap2 = PlotOnStaticMap( MyMap, L1[,2], L1[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "navy", add = T )

# Alive, Visibly Oiled
L2 = OilingCondMonth( Data=NorthernGannet, Oiling = "Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap3 = PlotOnStaticMap( MyMap2, L2[,2], L2[,3], FUN = points, lwd=2, pch=21,
cex=1.2, col = "red", add = T )

# Dead, Not Visibly Oiled
L3 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Dead", Month = "2010-09" )
MyMap4 = PlotOnStaticMap( MyMap3, L3[,2], L3[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "navy", add = T )

# Alive, Not Visibly Oiled
L4 = OilingCondMonth( Data=NorthernGannet, Oiling = "Not Visibly Oiled", Condition="Live", Month = "2010-09" )
MyMap5 = PlotOnStaticMap( MyMap4, L4[,2], L4[,3], FUN = points, lwd=2, pch=22,
cex=1.2, col = "red", add = T )

# Dead, Oiling Status Unknown
L5 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Dead", Month = "2010-09" )
MyMap6 = PlotOnStaticMap( MyMap5, L5[,2], L5[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "navy", add = T )

# Alive, Oiling Status Unknown
L6 = OilingCondMonth( Data=NorthernGannet, Oiling = "Unknown", Condition="Live", Month = "2010-09" )
MyMap7 = PlotOnStaticMap( MyMap6, L6[,2], L6[,3], FUN = points, lwd=2, pch=24,
cex=1.2, col = "red", add = T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.48,
legend = c("Visibly Oiled","Not Visibly Oiled","Oiling Status Unknown ", "Dead Northern Gannet",
"Live Northern Gannet","Oil Wellhead"), col = c("black","black","black","navy","red",
"black"), pch=c(21,22,24,16,16,7), pt.cex=1.5, bg="white", title="September 2010:")

dev.off()


# NO DATA for OCTOBER
```

B.4 Visualization Methods in R

B.4.1 R Code for Figure 31

```
# R code below may not work with the latest versions of R.

rm(list=ls())

library(ggplot2)
library(ReadImages)
library(RgoogleMaps)
library(MASS)
theme_set(theme_bw())

################################################################################
#################### preload functions of David Kahle      ####################
#################################################################################

ggimage <- function(image){
  require(ggplot2)

  if(length(dim(image)) == 2){
    message('creating black and white image...')
    image <- melt(image)
    names(image) <- c('row','column','fill')
    plot <- qplot(column, -row, data = image, geom = 'tile', fill = fill) +
      scale_fill_gradient(low = 'black', high = 'white')
  }

  if(length(dim(image)) == 3){
   message('creating color image...')
   image <- apply(image, 1:2, function(v) rgb(v[1], v[2], v[3]))
    image <- melt(image)
    names(image) <- c('row', 'column', 'fill')
    plot <- qplot(column, -row, data = image, geom = 'tile', fill = fill) +
      scale_fill_identity()
  }

  #return(plot) # remove first pound for the image in the case study
  plot +
    opts(
      axis.line = theme_blank(), axis.ticks = theme_blank(),
      axis.text.x = theme_blank(), axis.text.y = theme_blank(),
      axis.title.x = theme_blank(), axis.title.y = theme_blank(),
      axis.ticks.length = unit(0, "lines"),
```

```
      axis.ticks.margin = unit(0, "lines"),
      legend.position = "none",
      panel.background = theme_blank(),
      panel.border = theme_blank(),
      panel.grid.major = theme_blank(),
      panel.grid.minor = theme_blank(),
      panel.margin = unit(0, "lines"),
      plot.background = theme_blank(),
      plot.title = theme_blank(),
      plot.margin = unit(c(-1, -1, -1.5, -1.5), "lines")
    )
}



ggooglemap <- function(location = 'Deepwater', center = c(lat = 29.0, lon = -89.5),
type = c('color','bw')[1], rgbcoefs = c(0, 1, 0), zoom = 10,
    maptype = 'terrain',destfile = 'DeepwaterTemporaryMap.jpg', n_pix = 640)
{
  require(ggplot2)
  require(RgoogleMaps)
  require(ReadImages)


  GetMap(center = center[c('lat','lon')], size = c(n_pix, n_pix), zoom = zoom, format = 'jpg',
   maptype = maptype, destfile = destfile)

  # load map
  map <- read.jpeg(destfile)

  # deal with color
  if(type == 'color'){
    map <- apply(map, 1:2, function(v) rgb(v[1], v[2], v[3]))
  } else if(type == 'bw') {
   nrow <- nrow(map)
   ncol <- ncol(map)
    map <- grey(rgb2grey(map, coefs = rgbcoefs))
    map <- matrix(map, nrow = nrow, ncol = ncol)
  } else {
    stop('type must be either 661b56e4002b777f1f17cebd9787e84ff72f6537#39;color\' or
     661b56e4002b777f1f17cebd9787e84ff72f6537#39;bw\'', call. = FALSE)
  }

  # reshape map for plotting
  m_map <- melt(map)
  names(m_map) <- c('x','y','fill')
  m_map <- within(m_map,{
```

```
    x <- x - n_pix/2 - 1
    y <- y - n_pix/2 - 1
  })

  mapInfo <- list(lat = center['lat'], lon = center['lon'], zoom = zoom, map)
  XY_cent <- LatLon2XY.centered(mapInfo, center['lat'], center['lon'])
  #XY2LatLon(HouMapInfo, XY_cent$newX, XY_cent$newY)

  # geocode pixel references
  s <- (-n_pix/2) : (n_pix/2 - 1)
  lat_wrapper <- function(x) XY2LatLon(mapInfo, -n_pix/2, x)[1]
  lats <- apply(data.frame(s), 1, lat_wrapper)
  lon_wrapper <- function(y) XY2LatLon(mapInfo, y, -n_pix/2)[2]
  lons <- apply(data.frame(s), 1, lon_wrapper)

  # merge colors to latlons and return
  df_xy   <- expand.grid(x = s, y = s)
  df_ll   <- expand.grid(lat = rev(lats), lon = lons)
  df_xyll <- data.frame(df_xy, df_ll)
  df <- suppressMessages(join(df_xyll, m_map, type = 'right'))
  df <- df[,c('lon','lat','fill')]
  df
}



theme_nothing <- function (base_size = 12){
  structure(list(
    axis.line = theme_blank(),
    axis.text.x = theme_blank(), axis.text.y = theme_blank(),
    axis.ticks = theme_blank(),
    axis.title.x = theme_blank(), axis.title.y = theme_blank(),
    axis.ticks.length = unit(0, "lines"), axis.ticks.margin = unit(0, "lines"),
    legend.position = "none",
    panel.background = theme_rect(fill = 'white'),
    panel.border = theme_blank(),
    panel.grid.major = theme_blank(), panel.grid.minor = theme_blank(),
    panel.margin = unit(0, "lines"),
    plot.background = theme_rect(colour = 'white'),
    plot.title = theme_text(size = base_size * 1.2),
    plot.margin = unit(c(-1, -1, -1.5, -1.5), "lines")
  ), class = "options")
}


vplayout <- function(x, y)  viewport(layout.pos.row = x, layout.pos.col = y)
```

```
###################################################################################################

#-----------------------"Terrain Map of the Gulf of Mexico"----------------------------#


DeepwaterOil_latlon <- c(lon = -89.5, lat = 29.0)
DeepwaterMap <-ggooglemap(center = DeepwaterOil_latlon, zoom = 8)

hdtmap<-qplot(lon, lat, data = DeepwaterMap, geom = 'tile', fill = fill) +
  scale_fill_identity() +
  scale_x_continuous('Longitude') +
  scale_y_continuous('Latitude') +
  opts(legend.position="none", title = 'The Gulf of Mexico')+
  coord_equal()

jpeg(file = "Deepwater_Fig1_Gulf of Mexico.jpeg",width=1000, height=960, pointsize = 12,
quality = 75, bg = "white")

grid.newpage()
pushViewport(viewport(layout = grid.layout(1000,1000)))
print(hdtmap, vp = vplayout(1:1000, 1:1000))

dev.off()

#-----------------------"Fish Map for 2005"----------------------------#

#----------Reading fish-baseline DATA----------#
fish = read.csv(url("http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-baseline.csv"),
sep=",", head = TRUE, as.is=TRUE)

#----------separating data for 2005 and 2006---#
#We will use "if else statement"

Y<-length(fish[,1])
X<-length(fish[1,])

fish.2005<-c()
fish.2006<-c()

for(i in 1:Y){
if(substr(fish[i,4], nchar(fish[i,4]), nchar(fish[i,4])) == "5"){
fish.2005<-rbind(fish.2005, fish[i,])
}
else{
fish.2006<-rbind(fish.2006, fish[i,])
}
}
```

```
for(i in 5:X){
fish.2005[,i]<-as.numeric(fish.2005[,i])
fish.2006[,i]<-as.numeric(fish.2006[,i])
}

#-----------------data frame--------------------#

lat.2005 = fish.2005[,5]
lon.2005 = fish.2005[,6]
species.2005 = fish.2005[,1]

Deepwater.fish.2005=data.frame(species=species.2005,lat=lat.2005, lon=lon.2005)


# grab downtown google map
CityHall_latlon <- c(lon = -89.5, lat = 29.0)
DowntownMap <-ggooglemap(center = CityHall_latlon, zoom = 8)
lat_range <- range(DowntownMap$lat)
lon_range <- range(DowntownMap$lon)


## point plot
Deepwater.fish.2005 <- subset(Deepwater.fish.2005, lon_range[1] <= lon & lon <= lon_range[2] &
lat_range[1] <= lat & lat <= lat_range[2])


vcpplot<-ggplot() +
  geom_tile(aes(x = lon, y = lat, fill = fill), data = DowntownMap) +
  scale_fill_identity() +
  geom_jitter(aes(x = lon, y = lat, colour = species, size = species), fill = NA, alpha = I(3/4),
   data = Deepwater.fish.2005,
    position = position_jitter(width = .001, height = .001)) +
  scale_x_continuous('Longitude', limits = lon_range) +
  scale_y_continuous('Latitude', limits = lat_range) +
  scale_colour_discrete('') +
  scale_size_manual('', values = c('Atlantic croaker' = 4, 'blue crap' = 3, 'white shrimp' = 4)) +
  opts(legend.position = 'none', title = 'Deepwater Horizon Oil Spill_Fish species 2005') +
  coord_equal()

jpeg(file = "Deepwater_Fig2_Fish2005.jpeg",width=1000, height=960, pointsize = 12, quality = 75, bg = "white")

grid.newpage()
pushViewport(viewport(layout = grid.layout(1000,1000)))
print(vcpplot, vp = vplayout(1:1000, 1:1000))

dev.off()
```

```
#----------------------"Fish Contour Map for 2005"---------------------------#
#----------Reading fish-baseline DATA----------#
fish = read.csv(url("http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-baseline.csv"),
sep=",", head = TRUE, as.is=TRUE)

#----------separating data for 2005 and 2006---#
#We will use "if else statement"

Y<-length(fish[,1])
X<-length(fish[1,])

fish.2005<-c()
fish.2006<-c()

for(i in 1:Y){
if(substr(fish[i,4], nchar(fish[i,4]), nchar(fish[i,4])) == "5"){
fish.2005<-rbind(fish.2005, fish[i,])
}
else{
fish.2006<-rbind(fish.2006, fish[i,])
}
}

for(i in 5:X){
fish.2005[,i]<-as.numeric(fish.2005[,i])
fish.2006[,i]<-as.numeric(fish.2006[,i])
}

#-----------------data frame--------------------#

lat.2005 = fish.2005[,5]
lon.2005 = fish.2005[,6]
species.2005 = fish.2005[,1]

Deepwater.fish.2005=data.frame(species=species.2005,lat=lat.2005, lon=lon.2005)


# grab downtown google map
CityHall_latlon <- c(lon = -89.5, lat = 29.0)
DowntownMap <-ggooglemap(center = CityHall_latlon, zoom = 8)
lat_range <- range(DowntownMap$lat)
lon_range <- range(DowntownMap$lon)

## point plot
Deepwater.fish.2005 <- subset(Deepwater.fish.2005, lon_range[1] <= lon & lon <= lon_range[2] &
lat_range[1] <= lat & lat <= lat_range[2])
```

```
vccplot<-ggplot() +
  geom_tile(aes(x = lon, y = lat, fill = fill), data = DowntownMap) +
  geom_density2d(aes(x = lon, y = lat, colour = ..level..), bins = I(10), fill = NA,
   alpha = I(1/2), size = I(.75), data = Deepwater.fish.2005) +
  scale_colour_gradient2('Fish\nToxicity\nDensity', low = 'darkblue', mid = 'orange', high = 'red') +
  scale_x_continuous('Longitude', limits = lon_range) +
  scale_y_continuous('Latitude', limits = lat_range) +
  scale_fill_identity() +
  opts(legend.position = 'none', title = 'Deepwater Horizon Oil Spill_Fish species 2005') +
  coord_equal()


jpeg(file = "Deepwater_Fig3_Fish2005.jpeg",width=1000, height=960, pointsize = 12, quality = 75, bg = "white")

grid.newpage()
pushViewport(viewport(layout = grid.layout(1000,1000)))
print(vccplot, vp = vplayout(1:1000, 1:1000))

dev.off()


#-----------------------"Fish Weather Map for 2005"----------------------------#
#----------Reading fish-baseline DATA----------#
fish = read.csv(url("http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-baseline.csv"),
sep=",", head = TRUE, as.is=TRUE)

#----------separating data for 2005 and 2006---#
#We will use "if else statement"

Y<-length(fish[,1])
X<-length(fish[1,])

fish.2005<-c()
fish.2006<-c()

for(i in 1:Y){
if(substr(fish[i,4], nchar(fish[i,4]), nchar(fish[i,4])) == "5"){
fish.2005<-rbind(fish.2005, fish[i,])
}
else{
fish.2006<-rbind(fish.2006, fish[i,])
}
}

for(i in 5:X){
```

```
fish.2005[,i]<-as.numeric(fish.2005[,i])
fish.2006[,i]<-as.numeric(fish.2006[,i])
}

#-----------------data frame--------------------#

lat.2005 = fish.2005[,5]
lon.2005 = fish.2005[,6]
species.2005 = fish.2005[,1]

Deepwater.fish.2005=data.frame(species=species.2005,lat=lat.2005, lon=lon.2005)


# weather map
CityHall_latlon <- c(lon = -89.5, lat = 29.0)
DowntownMap <-ggooglemap(center = CityHall_latlon, zoom = 8, maptype = 'hybrid')
lat_range <- range(DowntownMap$lat)
lon_range <- range(DowntownMap$lon)


vclatlon <- Deepwater.fish.2005[,c('lon','lat')]
vclatlon <- na.omit(Deepwater.fish.2005[,c('lon','lat')])
vclatlon <- subset(vclatlon,
  lon_range[1] <= lon & lon <= lon_range[2] &
  lat_range[1] <= lat & lat <= lat_range[2]
)

den <- kde2d(vclatlon$lon, vclatlon$lat, n = 320,
  lims = c(lon_range, lat_range))

kde_df <- expand.grid(
  lon = seq.int(lon_range[1], lon_range[2], length.out = 320),
  lat = seq.int(lat_range[1], lat_range[2], length.out = 320)
)
kde_df$density <- melt(den$z)$value

summary(kde_df$density)
den_fill_scale <- scale_colour_gradient2(low = 'white', mid = 'darkgreen',
  high = 'red') #, midpoint = 225)
den_fill_scale$train(kde_df$density, T)
kde_df$density_s <- den_fill_scale$map(kde_df$density)
kde_df$density_zeroone <- pmin(kde_df$density / max(kde_df$density), .9)


big_plot <- ggplot() +
  geom_tile(aes(x = lon, y = lat, fill = fill), data = DowntownMap) +
  geom_tile(aes(x = lon, y = lat, fill = density_s, alpha = density_zeroone),
```

```
    data = kde_df) +
  scale_x_continuous('Longitude', limits = lon_range) +
  scale_y_continuous('Latitude', limits = lat_range) +
  scale_alpha(to = c(0, .9)) +
  scale_fill_identity() +
  opts(
    legend.position = 'none',
    title = 'Deepwater Horizon Oil Spill Weather Map_Fish 2005'
  ) +
  coord_equal()

little_plot <- ggplot() +
  geom_tile(aes(x = lon, y = lat, fill = density_s, alpha = density_zeroone),
    data = kde_df) +
  scale_alpha(to = c(0, .9)) +
  scale_fill_identity() +
  coord_equal() +
  theme_nothing()


jpeg(file = "Deepwater_Fig4_Fish2005.jpeg",width=1000, height=960, pointsize = 12, quality = 75, bg = "white")

grid.newpage()
pushViewport(viewport(layout = grid.layout(1000,1000)))
print(big_plot, vp = vplayout(1:1000, 1:1000))
#print(little_plot, vp = vplayout(625:897, 740:955))
print(little_plot, vp = vplayout(687:897, 740:960))

dev.off()
```

B.4.2 R Code for Figure 32

```
# R code below may not work with the latest versions of R.

rm(list=ls())

library(ggplot2)
library(ReadImages)
library(RgoogleMaps)
library(MASS)
theme_set(theme_bw())

################################################################################
```

```
#################### preload functions of David Kahle      ####################
################################################################################

ggimage <- function(image){
  require(ggplot2)

  if(length(dim(image)) == 2){
    message('creating black and white image...')
    image <- melt(image)
    names(image) <- c('row','column','fill')
    plot <- qplot(column, -row, data = image, geom = 'tile', fill = fill) +
      scale_fill_gradient(low = 'black', high = 'white')
  }

  if(length(dim(image)) == 3){
   message('creating color image...')
   image <- apply(image, 1:2, function(v) rgb(v[1], v[2], v[3]))
    image <- melt(image)
    names(image) <- c('row', 'column', 'fill')
    plot <- qplot(column, -row, data = image, geom = 'tile', fill = fill) +
      scale_fill_identity()
  }

  #return(plot) # remove first pound for the image in the case study
  plot +
    opts(
      axis.line = theme_blank(), axis.ticks = theme_blank(),
      axis.text.x = theme_blank(), axis.text.y = theme_blank(),
      axis.title.x = theme_blank(), axis.title.y = theme_blank(),
      axis.ticks.length = unit(0, "lines"),
      axis.ticks.margin = unit(0, "lines"),
      legend.position = "none",
      panel.background = theme_blank(),
      panel.border = theme_blank(),
      panel.grid.major = theme_blank(),
      panel.grid.minor = theme_blank(),
      panel.margin = unit(0, "lines"),
      plot.background = theme_blank(),
      plot.title = theme_blank(),
      plot.margin = unit(c(-1, -1, -1.5, -1.5), "lines")
    )
}



ggooglemap <- function(location = 'Deepwater', center = c(lat = 29.0, lon = -89.5),
type = c('color','bw')[1], rgbcoefs = c(0, 1, 0), zoom = 10,
```

```
    maptype = 'terrain',destfile = 'DeepwaterTemporaryMap.jpg', n_pix = 640)
{
  require(ggplot2)
  require(RgoogleMaps)
  require(ReadImages)


  GetMap(center = center[c('lat','lon')], size = c(n_pix, n_pix), zoom = zoom, format = 'jpg',
   maptype = maptype, destfile = destfile)

  # load map
  map <- read.jpeg(destfile)

  # deal with color
  if(type == 'color'){
    map <- apply(map, 1:2, function(v) rgb(v[1], v[2], v[3]))
  } else if(type == 'bw') {
   nrow <- nrow(map)
   ncol <- ncol(map)
    map <- grey(rgb2grey(map, coefs = rgbcoefs))
    map <- matrix(map, nrow = nrow, ncol = ncol)
  } else {
    stop('type must be either 661b56e4002b777f1f17cebd9787e84ff72f6537#39;color\' or 661b56e4002b777f1f17cebd9787e84ff7
  }

  # reshape map for plotting
  m_map <- melt(map)
  names(m_map) <- c('x','y','fill')
  m_map <- within(m_map,{
    x <- x - n_pix/2 - 1
    y <- y - n_pix/2 - 1
  })

  mapInfo <- list(lat = center['lat'], lon = center['lon'], zoom = zoom, map)
  XY_cent <- LatLon2XY.centered(mapInfo, center['lat'], center['lon'])
  #XY2LatLon(HouMapInfo, XY_cent$newX, XY_cent$newY)

  # geocode pixel references
  s <- (-n_pix/2) : (n_pix/2 - 1)
  lat_wrapper <- function(x) XY2LatLon(mapInfo, -n_pix/2, x)[1]
  lats <- apply(data.frame(s), 1, lat_wrapper)
  lon_wrapper <- function(y) XY2LatLon(mapInfo, y, -n_pix/2)[2]
  lons <- apply(data.frame(s), 1, lon_wrapper)

  # merge colors to latlons and return
  df_xy   <- expand.grid(x = s, y = s)
  df_ll   <- expand.grid(lat = rev(lats), lon = lons)
```

```
  df_xyll <- data.frame(df_xy, df_ll)
  df <- suppressMessages(join(df_xyll, m_map, type = 'right'))
  df <- df[,c('lon','lat','fill')]
  df
}



theme_nothing <- function (base_size = 12){
  structure(list(
    axis.line = theme_blank(),
    axis.text.x = theme_blank(), axis.text.y = theme_blank(),
    axis.ticks = theme_blank(),
    axis.title.x = theme_blank(), axis.title.y = theme_blank(),
    axis.ticks.length = unit(0, "lines"), axis.ticks.margin = unit(0, "lines"),
    legend.position = "none",
    panel.background = theme_rect(fill = 'white'),
    panel.border = theme_blank(),
    panel.grid.major = theme_blank(), panel.grid.minor = theme_blank(),
    panel.margin = unit(0, "lines"),
    plot.background = theme_rect(colour = 'white'),
    plot.title = theme_text(size = base_size * 1.2),
    plot.margin = unit(c(-1, -1, -1.5, -1.5), "lines")
  ), class = "options")
}


vplayout <- function(x, y)  viewport(layout.pos.row = x, layout.pos.col = y)

##############################################################################################################

#----------Reading fish-baseline DATA----------#
fish = read.csv(url("http://streaming.stat.iastate.edu/dataexpo/2011/resources/data/fish-baseline.csv"),
sep=",", head = TRUE, as.is=TRUE)

#----------separating data for 2005 and 2006---#
#We will use "if else statement"

Y<-length(fish[,1])
X<-length(fish[1,])

fish.2005<-c()
fish.2006<-c()

for(i in 1:Y){
if(substr(fish[i,4], nchar(fish[i,4]), nchar(fish[i,4])) == "5"){
fish.2005<-rbind(fish.2005, fish[i,])
```

```
}
else{
fish.2006<-rbind(fish.2006, fish[i,])
}
}

for(i in 5:X){
fish.2005[,i]<-as.numeric(fish.2005[,i])
fish.2006[,i]<-as.numeric(fish.2006[,i])
}

#-----------------data frame--------------------#

lat.2005 = fish.2005[,5]
lon.2005 = fish.2005[,6]
species.2005 = fish.2005[,1]

Deepwater.fish.2005=data.frame(species=species.2005,lat=lat.2005, lon=lon.2005)


source(url("http://www.math.usu.edu/~symanzik/teaching/2011_stat6560/RDataAndScripts/GetMap.R"))
# this is needed while RgoogleMaps is being updated on CRAN


# weather map
CityHall_latlon <- c(lon = -89.5, lat = 29.0)
DowntownMap <-ggooglemap(center = CityHall_latlon, zoom = 8, maptype = 'hybrid')
lat_range <- range(DowntownMap$lat)
lon_range <- range(DowntownMap$lon)


vclatlon <- Deepwater.fish.2005[,c('lon','lat')]
vclatlon <- na.omit(Deepwater.fish.2005[,c('lon','lat')])
vclatlon <- subset(vclatlon,
  lon_range[1] <= lon & lon <= lon_range[2] &
  lat_range[1] <= lat & lat <= lat_range[2]
)

den <- kde2d(vclatlon$lon, vclatlon$lat, n = 320,
  lims = c(lon_range, lat_range))

kde_df <- expand.grid(
  lon = seq.int(lon_range[1], lon_range[2], length.out = 320),
  lat = seq.int(lat_range[1], lat_range[2], length.out = 320)
)
kde_df$density <- melt(den$z)$value
```

```
summary(kde_df$density)
den_fill_scale <- scale_colour_gradient2(low = 'white', mid = 'darkgreen',
  high = 'red') #, midpoint = 225)
den_fill_scale$train(kde_df$density, T)
kde_df$density_s <- den_fill_scale$map(kde_df$density)
kde_df$density_zeroone <- pmin(kde_df$density / max(kde_df$density), .9)


big_plot <- ggplot() +
  geom_tile(aes(x = lon, y = lat, fill = fill), data = DowntownMap) +
  geom_tile(aes(x = lon, y = lat, fill = density_s, alpha = density_zeroone),
    data = kde_df) +
  scale_x_continuous('Longitude', limits = lon_range) +
  scale_y_continuous('Latitude', limits = lat_range) +
  scale_alpha(to = c(0, .9)) +
  scale_fill_identity() +
  opts(
    legend.position = 'none',
    title = 'Deepwater Horizon Oil Spill Weather Map_Fish 2005'
  ) +
  coord_equal()

little_plot <- ggplot() +
  geom_tile(aes(x = lon, y = lat, fill = density_s, alpha = density_zeroone),
    data = kde_df) +
  scale_alpha(to = c(0, .9)) +
  scale_fill_identity() +
  coord_equal() +
  theme_nothing()


pdf(file = "Deepwater_Fig4_Fish2005_2.pdf",width=12, height=10, pointsize = 10, bg = "white")
# Try to change width and height and search ?pdf

grid.newpage()
pushViewport(viewport(layout = grid.layout(1000,1000)))
print(big_plot, vp = vplayout(1:1000, 1:1000))
print(little_plot, vp = vplayout(687:897, 740:960))

dev.off()
```

B.4.3 R Code for Figures 33 and 34

```
rm(list=ls())
```

```
#Save the zip file to your directory. Then choose the option "Install from local zip"
#within R. Activate via library(loa) as usual. Then run the example code below.

library(loa)
require(MASS)

source("D:/EDUCATION/USU courses/STATISTICS COURSES/RESEARCH/Deepwater/4_FISH/fish-baseline.R")

jpeg("loa_fish2005_fig1.jpg", width=7.5, height=7.5, units="in", res=90)
googleMap( ~ latitude * longitude, data = fish.2005, cex=2)
dev.off()

jpeg("loa_fish2005_fig2.jpg", width=7.5, height=7.5, units="in", res=90)
googleMap(NPH ~ latitude * longitude, data = fish.2005)
dev.off()

jpeg("loa_fish2005_fig3.jpg", width=7.5, height=7.5, units="in", res=90)
googleMap(NPH ~ latitude * longitude, data = fish.2005, col="red", alpha=0.5)
dev.off()


lat = fish.2005$latitude
lon = fish.2005$longitude

#my new panel...
panel.new<- function(x, y, ...){
#xy <- kde2d(x, y)
xy <- kde2d(x, y, lims = c(map$xlim, map$ylim))
xy <- con2tr(xy)
panel.contourplot(xy$x, xy$y, xy$z,
subscripts=seq(nrow(xy)),
contour=TRUE, region=FALSE)
}

map <- RgoogleMapsWrapper(lat, lon, maptype="terrain", zoom=8)
googleMap(~lat*lon, map=map, type="n")


#--------contour map---------------------#
jpeg("loa_fish2005_fig4.jpg", width=7.5, height=7.5, units="in", res=90)
googleMap(~lat*lon, data=fish.2005, panel=panel.new)
dev.off()
```

B.4.4 *PBSmapping* Method of Remote Sensing Data

```
library(RgoogleMaps)
library(PBSmapping)

bb <- qbbox(c(28,29,30), c(-92.2,-87,-85.6),TYPE = "all",
margin = list(m=rep(5, 4), TYPE = c("perc", "abs")[1]))
MyMap <- GetMap.bbox(bb$lonR, bb$latR, destfile = "MyTile3.png")

PlotOnStaticMap(MyMap)

# Oil Spill area for May 31, 2010
shpFile <-  'D:\\ ... \\20100531_1558_A1.shp'
shp = importShapefile(shpFile, readDBF = TRUE)
PlotPolysOnStaticMap(MyMap, shp, lwd = 1, cex = 3, col = "gray60", add = F)


# Oil spill location
PlotOnStaticMap( MyMap, lat = 28.738140, lon = -88.365945, FUN = points, lwd=2,
pch = 7, cex=2.5, col = "black", add=T )

legend( LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newX*.995,
LatLon2XY.centered( MyMap, MyMap$BBOX$ll[1], MyMap$BBOX$ll[2] )$newY*.8,
legend = c("Oil Wellhead"), col = "black", pch=7, pt.cex=1.5, bg="white")
text( 200, -225, "Oil spill area \n for May 31, 2010", adj = c(0.5, 0.5), col = "black", cex = 1.3 )

dev.off()
```